THE BLUE SHARK.

CASSELL'S

NATURAL HISTORY.

EDITED BY

P. MARTIN DUNCAN, M.B. (LOND.), F.R.S., F.G.S.,

PROFESSOR OF GEOLOGY IN AND HONORARY FELLOW OF KING'S COLLEGE, LONDON,
CORRESPONDENT OF THE ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.

VOL. V.

ILLUSTRATED.

CASSELL PETTER, GALPIN & CO.:

LONDON, PARIS & NEW YORK.

1881.

PISCES.

PROFESSOR H. G. SEELEY, F.R.S., F.G.S., ETC.

INVERTEBRATA (INTRODUCTION).

PROFESSOR P. MARTIN DUNCAN, M.B. (LOND.), F.R.S., F.G.S., ETC.

MOLLUSCA.

HENRY WOODWARD, LL.D., F.R.S., F.G.S., ETC.

TUNICATA.

HENRY WOODWARD, LL.D., F.R.S., F.G.S., ETC.

MOLLUSCOIDA (BRACHIOPODA AND BRYOZOA).

AGNES CRANE.

INSECTA (INTRODUCTION).

W. S. DALLAS, F.L.S.

COLEOPTERA.

H. W. BATES, F.L.S.

HYMENOPTERA.

W. S. DALLAS, F.L.S.

CONTENTS.

CLASS PISCES.—FISHES.

CHAPTER I.

GENERAL INTRODUCTION—THE ANATOMY AND OTHER CHARACTERISTICS OF FISHES.

CHAPTER II.

THE PALÆICHTHYES, OR FISHES OF ANCIENT TYPES.

CHAPTER III.

THE PLECTOGNATHI.—THE LOPHOBRANCHII.—THE ANACANTHINI.

CHAPTER IV.

THE ORDERS PHARYNGOGNATHI AND ACANTHOPTERYGII.

CHAPTER V.

ORDER ACANTHOPTERYGII (*concluded*). PAGE

CHAPTER VI.

THE ORDER PHYSOSTOMI.

CHAPTER VII.

PHYSOSTOMI (*concluded*)—CYCLOSTOMATA—LEPTOCARDII.

THE ANIMALS WITHOUT BACKBONES—THE INVERTEBRATA.

INTRODUCTION.

INVERTEBRATA.—TYPE MOLLUSCA.

CHAPTER I.

THE CEPHALOPODA.

CLASS INSECTA.

CHAPTER I.

ANATOMY OF INSECTS. PAGE

ORDER COLEOPTERA.

CHAPTER II.

THE BEETLES ORDER—CARNIVOROUS BEETLES.

CHAPTER III.

CARNIVOROUS, ANOMALOUS, AND BURYING-BEETLES.

CHAPTER IV.

THE LAMELLICORN AND SERRICORN BEETLES.

CHAPTER V.

SECTIONS HETEROMERA, TETRAMERA, AND TRIMERA.

ORDER HYMENOPTERA.

CHAPTER VI.

ACULEATA, OR STINGING HYMENOPTERA.

LIST OF ILLUSTRATIONS.

CASSELL'S NATURAL HISTORY.

THE COMMON PIKE.

CLASS PISCES.—FISHES.

CHAPTER I.

GENERAL INTRODUCTION.—THE ANATOMY AND OTHER CHARACTERISTICS OF FISHES.

Immense Variety of Forms—Characteristics of the Class—Industrial Importance to Man—Fecundity—Colour—Mental Endowments—Their General Structure—The Lowest Type of Fish—Structural Features in Sharks and Rays—The Skull—Peculiarities in the Lepidosiren—Skull of Codfish—The Sense Capsules—Teeth and Jaws—The Branchial Arches—The Muscles of Fishes—The Skin and Mucous System—To what Causes the Colour of Fishes is Due—The Scales of Fishes—Agassiz's Classification based on Scales—The Nervous System—The Spinal Cord—The Brain—Organs of Smell, Sight, and Hearing—The Electric Organs—The Teeth of Fishes—The Alimentary Canal—The Liver—The Air-bladder—The Blood—The Heart—The Gills—Fins and their Functions—Classification of the Fishes.

FISHES are the only primary division of the Vertebrata which live in water, and have no representatives passing their lives upon land or in the air. This condition of existence is probably the cause of the close correspondence in bodily form in the majority of fishes, which progress through the water chiefly by movements of the tail, and use the fins as organs with which to steer a path. Clear as is the idea which rises in the mind at the mention of a fish, the multitudes of forms which fishes exhibit are greater, perhaps, than those to be found in any of the preceding great

groups of animals which have already been described. The slender form of the Lamprey or Eel contrasts with the expanded body of the Turbot or Plaice; the short deep form of the Sun-fish is unlike the broad, flattened, and long-tailed Skate; the Sea Horses, when attached by their prehensile tails, at first sight present none of the familiar characteristics of fishes; the Flying-fish, which have the fins so expanded as to serve some of the purposes of wings, present a remarkable contrast to the spheroidal spiny body of the Globe-fish; while the Hammer-headed Shark exhibits a form of body in some respects more singular still. When we turn to details of proportion and structure, and contrast the shapes of the head or of the tail, the variety among fishes is altogether exuberant. In the covering of the body there is not so much scope for variation, for although some are contained in a box of bony plates, or mailed with armour far heavier in proportion than that of the knights of old, and some fishes have, on the other hand, scales so delicate that they are detected with difficulty, yet by far the larger number of living fishes are clothed with soft scales, which impart to them much of their beauty, and differ in little more than size and details of ornament in the multitudinous genera. But beyond the claims upon our attention which the external forms of fishes certainly make, an interest of a far higher kind is always aroused by their wonderful habits. Here we find the herbivorous and carnivorous types of the land reproduced. Many fishes—like the Sword-fish, for instance—seem specially moulded into shape for purposes of slaughter; many fishes, like most of those with transversely-expanded bodies, pass their lives more or less quietly on the bottom of the sea, and simulate the sand they rest upon; other groups, like Eels, dive into the sand as though it were their natural home; others, again, like the Gurnards, crawl with their appendages at the sides of the head, almost like some of the Crabs, when they are not freely swimming. Some fishes, like the Sturgeon, find their home indifferently in fresh or salt water; several, like the Salmon, require to descend annually from the river to the sea. Multitudes of fishes travel in fellowship year by year over a large portion of the ocean, a few fresh-water fishes journey over land, and one or two are sometimes found roosting like birds in the branches of trees.

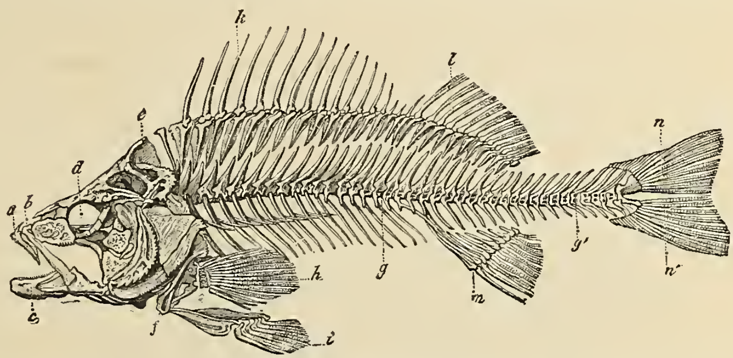
The industries which fishes have contributed to develop have given this group of animals an importance scarcely second to mammals and birds. No small proportion of the food of mankind is obtained by the fleets of fishing-boats around the coasts, and by the humbler nets, and snares, and lines with which fishes are captured in rivers and lakes. The use of fish for manure is of ancient date; the capture of fishes for the manufacture of medicinal and other oils, gelatine, and isinglass is carried on on a large scale; the skins of Sharks have always been valued for the decoration of some kinds of military weapons no less than by the cabinet-maker for their rasping properties. Much of the artificial jewellery, which resembles pearls so closely as almost to equal the natural production of the sea-shell *Avicula margaritifera*, owes its beauty to a preparation from the scales of the Bleak and other fishes.

The fecundity of fishes far surpasses that of any other group of vertebrated animals. The eggs laid by a single fish sometimes may be counted by millions. They are almost always small—as may be seen in the ordinary hard roe of the fishes which are eaten—and are frequently minute. They pass through no metamorphosis, as do the young in their development among the higher group named Amphibia; but occasionally fishes are viviparous, and then the young are retained within the body of the parent until they have reached a relatively large size. Fishes furnish us with the smallest examples of the Vertebrates which are known, and also with some of the biggest forms, though they never make any approach to the giant length of the larger Whales. By far the greater number of fishes are of relatively small size.

As with mammals and birds, the great majority of fishes are characterised by comparatively dull colours, which probably serve to conceal them from enemies, and have been developed as a means of enabling them to mimic the aspects of the regions of sea and river which they frequent. But all are not so simply decorated. The brilliant colours of the gold and silver and violet Carp are well known. Many fishes are striped and spotted, or burnished with colours which almost rival those of gaudy birds, and it would be difficult to name a tint which could not be matched among some representatives of the fish class. Too little, however, is known of the habits and ways of life of these highly-coloured fishes to enable us to judge how far they are an advantage to the species which are thus characterised.

In the matter of mental endowment fishes are probably but little, if at all, inferior to the majority of the so-called higher animals. The angler knows well their caution, discrimination, cunning, and boldness, and how often his own powers and patience are exerted in vain in entrapping a fish who has grown wise as well as old in observation of the phenomena of the river in which he lives. Fishes would appear to be capable of affection, since Sharks, at least, frequently swim in pairs. Some genera are capable of being trained, and a few are known to be gifted with vocal organs which, to judge from the analogy of higher animals, may fairly be regarded as a means for the inter-communication or expression of emotions and experiences. Removed as fishes are from the conditions of daily observation by living in water, fewer observations have necessarily been made upon their intellectual characteristics than is the case with animals which can be more easily studied.

In their general structure or anatomy fishes are usually well distinguished from other animals. Their most distinctive structures are, perhaps, the possession of gills and an air-bladder. But they are no less well defined by the peculiar forms assumed by the limbs which we call fins, and by the simplicity of the plan upon which the immense muscles, which form the larger part of the fish's body, are arranged. The variety in structure, however, presented by fishes is so great that the lowest type—represented by the Lancelet—seems almost to pass beyond the limits of the fish group, standing alone in its simplicity and in many details of structure in which a parallel can be traced with yet lower animals. Other fishes also diverge so far from the typical forms as to possess lungs, as may be seen in the Ceratodus of the Australian rivers, and in the Mud-fish, called Lepidosiren. It may be useful briefly to mention the chief characteristics of the several groups of organs of this class of animals.



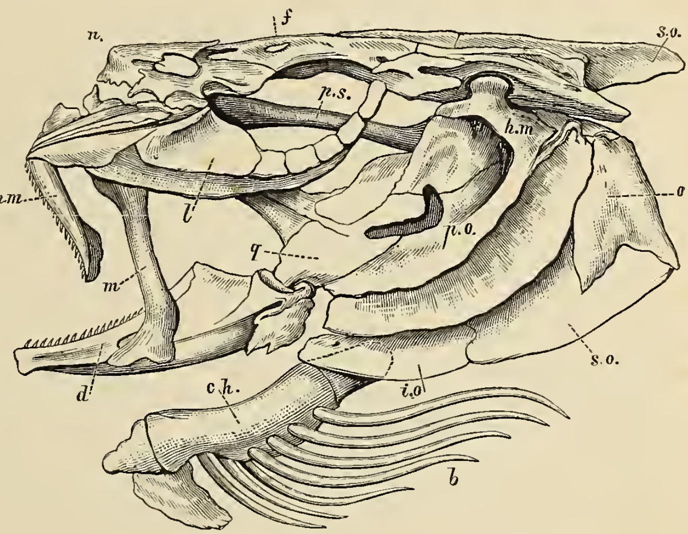
SKELETON OF THE COMMON PERCH.

a, Pre-maxillary Bone; *b*, Maxillary Bone; *c* Under Jaw; *d*, Palatine Arch; *e*, Cranium; *f*, Inter-operculum; *g g′*, Vertebral Column; *h*, Pectoral Fin; *i*, Ventral Fin; *k*, *l*, Dorsa Fins; *m*, Anal Fin; *n n′*. Candal Fin.

In the lowest type of fish, of which the Lancelet (*Amphioxus lanceolatus*) is the only representative, the cranium is merely a forward continuation of the rod which represents the vertebral column. This rod is named the *notochord*, or *chorda dorsalis*, and consists of a fibro-gelatinous substance, which is not covered with cartilage or with bony matter. This gives a very imperfect conception of the skull as usually seen in fishes; yet a jointed cartilaginous arch extends downward round the region of the mouth, and is a foreshadowing of the arch which is more perfectly developed around the mouth in the Lampreys. In simplicity of skull-structure the Sharks and Rays are the next step in the upward series, but there are many points in connection with these animals which lead to the belief that they are among the highest types of fish. The *notochord* is now converted into firm granular cartilage, sheathed in bone, and divided into segments by bone deposited in its substance; but it extends forward along the base of the skull, and develops two oblong convex surfaces, which are termed the occipital condyles, by which the back of the skull unites with the first vertebra. This mode of union of the skull with the vertebral column is characteristic of amphibians and mammals, and since the other Vertebrates have the skull united to the vertebral column by a single occipital condyle, it has sometimes been thought that we may discern herein a special indication of affinity between the skulls of Sharks and those of the Amphibia, which, it will be remembered, possess, when they commence their existence, many of the structures of fishes. There is no distinction of bones, however, in the brain-case, but the bony matter is deposited in countless little cells. Its base is flat; the sides are contracted; it is usually flattened above, with one or more open spaces, or *fontenelles*, which are covered only with

membrane. Indeed, this bony structure cannot truly be called a brain-case, since it is merely a covering on the outside of the cartilage which contains the brain. The arches appended to this cranium are a single strong pedicle on each side, which is articulated to an angular posterior process, and has attached to it the arch which is called the mandible, or lower jaw, and the arch which is considered to correspond to the tongue-bone in reptiles and birds, and is hence called the hyoid. The maxillary arch, or upper jaw, is closely joined to its fellow in front by a ligament, and is attached by ligaments to the anterior part of the cranial region, and is prolonged backward so as to articulate with the lower jaw. Each lateral half of the jaw consists of a single cartilage, or cartilage sheathed in bone, and thus far is comparable only with the jaws in mammals. According to Professor Owen, there are also cartilages which represent the palatine and pterygoid bones in the Monk-fish and in a Brazilian Torpedo. Four or five cartilaginous rays diverge from the hinder margin of the pedicle which supports the jaws, and have stretched upon them a membrane which corresponds to the operculum in bony fishes. The hyoid arch in the Shark family usually consists of two long and strong lateral pieces, which are united to a middle symmetrical piece below, which is flattened, termed the basi-hyoid. The two lateral portions, which rise from this like horns, and are hence termed the cerato-hyoids, give off short cartilaginous processes from their hinder margins, which correspond to the bones which are termed branchiostegal rays in bony fishes, and support the outer membrane of the sac which contains the gills. The five branchial arches which extend backward behind the hyoid arch are suspended from the sides of the front vertebræ of the trunk, just as in the Lamprey. In Sharks three strong cartilages are prolonged forward from the head, which coalesce in the middle line and form the remarkable snout. In these fishes the shoulder girdle is suspended a little behind the head. The ear is contained in a cartilaginous capsule in the walls of the cranium, the eye is united by a cartilaginous pedicle with the orbit, and the nasal sacs are arched over by nasal processes from the skull. Another modification of skull is seen in the Lepidosiren, where the separate bones of the skull are distinctly formed. The fibrous sheath of the notochord is ossified at the anterior end, and the ex-occipital bones rise from it, and expand and converge so as to meet above the foramen magnum. A large cartilaginous capsule surrounds the internal ear, but there is a long basi-cranial bone with cartilaginous plates at the sides. Other bones of the upper part of the skull also have representatives. Each branch of the lower jaw consists now of two pieces—the hinder portion, termed the articular, and the anterior, termed the dentary, though the two dentary pieces have become united together in the middle line in front. There are some slight representatives of the opercular arch. There is a single cerato-hyoid bone on each side, but no basi-hyoid. In one of his lectures Professor Owen remarks of this fish:—"I believe it to manifest, upon the whole, the highest grade which is attained in the class of fishes, or in the direct progress to perfection in what may be termed the vertebrate high road. The true or typical osseous fishes deviate from this road into bypaths of their own, and superadd endless complexities, of which we shall seek in vain for homologous parts in reptiles, birds, or mammals. The Lepidosiren's skeleton presents the closest resemblance to that of the lowest class of reptiles, though it differs therefrom both by a little less and a little more development." The skull in osseous fishes is altogether different. It may be convenient, as the modifications which it presents are so multitudinous, to bear in mind as one type the skull of the Codfish (*Gadus morrhua*), which is one of our largest and commonest British species. The head is larger in proportion to the trunk in fishes than in any other class of animals. It is more or less conical. The base of the cone joins the trunk without any intervening neck; the jaws are usually at the apex of the cone, which is flattened above, and has the sides more or less converging below. The eyes are large, and the orbits communicate with each other. There are two lateral fissures behind the head, which are called the gill-apertures, and are opened and closed by special mechanism. Besides receiving the food, the mouth takes in streams of water for respiration, which, after bathing the gills, escape by the gill-apertures or openings behind the operculum. The head also contains the heart and the whole of the breathing organs, and the anterior limbs are often in very close union with the skull. There are more bones in the head of a fish than in the head of any other animal. Most of these bones unite with each other by overlapping, like scales. The brain is contained in a cranial cavity, so that the bones fit closely upon it. The upper surface of the head is often marked by longitudinal crests, but

it does not often happen that the temporal muscles, which work the lower jaw, extend to the upper surface of the cranium, though this sometimes occurs, as in the Conger Eel and in the Lepidosiren. The bones of the skull, as in man, are divided into those of the brain-case and those of the face, but in fishes the facial bones are far more developed than in man. The hindermost bone at the back of the skull, by which it joins the first vertebra, varies a good deal in form. In most fishes, as in the Carp, it is a deep conical cup, but in the Holibut it is almost flat, and in Fistularia it presents a convex surface, which is exactly comparable with the condition seen in a Lizard or Crocodile. This bone, which is termed the basi-occipital, in many fishes has a process prolonged downward from its under side, and in the Carp this broad triangular plate supports the large upper grinding-tooth in the throat, reminding one of the way in which processes from the neck vertebræ are prolonged into the œsophagus in certain Snakes and Lizards. There are two bones rising from the basi-occipital which arch over the beginning of the brain; they are termed the ex-occipitals. They are usually perforated for the pneumo-gastric nerve, and sometimes for other nerves also. The bone above these is called the supra-occipital. In the Cod it is prolonged backward in a median spine; in the bony Pike (*Lepidosteus*) it is double, being divided by a suture in the middle line. Sometimes the crest of the bone is exceedingly lofty, as in the Light Horseman fish (*Ephippus*), and sometimes absent, as in the sucking fish Remora. At the sides of the ex-occipitals are two bones, termed by Owen par-occipitals, and by Huxley opisthotic bones. The distinction of these bones in the lower Vertebrates is a characteristic feature of the skull, but in the Polypterus they unite with the ex-occipital bones, as in Batrachian reptiles, and in the Chad they unite with the mastoid bones, as in the Chelonia. The organ of hearing in fishes is usually large. In front of this girdle of cranial bones, which Professor Owen long ago compared to one of the trunk vertebræ, is a similar series of bones with a median basal bone, now called the para-sphenoid, and closely resembling the parasphenoid of Amphibians, which reaches along the greater part of the base of the skull, exactly as in that group. In the flat fishes its anterior end is twisted upon one side of the skull. It is always smooth below, and in the genus Polypterus the bones which rise from its sides are blended with it. There is some difference of opinion with regard to the names to be given to these bones. The hindermost bone is termed by Owen ali-sphenoid, and by Huxley prootic. These bones are arched over by the parietals. In the Salmon family the two parietals soon unite together. In the Siluroid fishes they also unite with the supra-occipital bone, but in many osseous fishes the supra-occipital bone extends between them. They are always flattened above. In some fishes they are perforated by nerves which supply the vertical fins of the back. In front of the parietal bones is the principal frontal, which roofs over the orbits in all animals. It carries a median crest in the Cod and some fishes, and varies in shape with the form of the skull. In the Tunny each frontal has a crest of its own, and in some Siluroid fishes and the Loach there is a fontenelle between the frontal and parietal bones which corresponds in position with the so-called *foramen-parietale*, which is characteristic of many fossil and living reptiles. In the flat fishes the frontal is single. Behind it at the sides are the post-frontal bones, which assist in arching over the auditory cavities, and help to furnish a support for



SKULL OF CODFISH (*Gadus morrhua*). [*After Owen.*]

l, Lacrymal; *n*, Nasal; *f*, Frontal; *s.o.*, Supra-occipital; *pm*, Pre-maxillary; *m*, Maxillary; *i.o.*, Inter-operculum; *s.o.*, Sub-operculum; *o*, Operculum; *p.o.*, Pre-operculum; *h.m.*, Hyo-mandibular; *q*, Quadrate; *c.h.*, Cerato-hyal; *b*, Branchiostegal Rays; *ps*, Para-sphenoid; *d*, Dentary.

the tympanic pedicle. At their anterior corners are the pre-frontal bones, which defend and support the olfactory prolongation of the brain, and form the front border of the orbit. On the base of the skull, wedged into the para-sphenoid, is the vomer; its upper surface supports the nasal bones. In the genus Lepidosteus it is divided longitudinally into two. In many fishes the vomer carries teeth. The pre-frontals and nasals are both sometimes blended with the vomer. The nasal bone is broad in the Salmon, but varies in shape in other fishes. In the genus Lophius and in the Diodonts it is unossified, being represented by membrane. The nasal bone completely divides the nasal cavity into two lateral pits. Between the orbits there is often a partition, which is sometimes cartilaginous and sometimes membranous. The turbinal bones of man, on which the olfactory nerve is spread out, are represented in the fish, and placed at the sides of the nasal bones. The nasal bone sometimes supports teeth, and teeth are frequently found on the palatine bones.

The sense-capsules are well fitted into cavities of the skull in bony fishes. The auditory organ becomes blended with the cartilaginous base of the skull in Lepidosiren, and there are distinct otic bones, which protect the labyrinth of the ear in many bony fishes. These auditory capsules are often closed externally, but have a wide opening into the cranial cavity. The eye in cartilaginous fishes is contained in a cartilaginous capsule, but in most osseous fishes the capsule is bony. Bony plates are developed in some fishes in the sclerotic or hard outermost covering of the eye. In most fishes the bony orbits for the eyes communicate with each other, but the Shads, Hydrocyon, Synbranchus, Cyprinus, and many other genera have a bony septum between the orbits, and in the Ganoid fishes of the genera Lepidosteus and Polypterus the orbits are divided, as among the Batrachia, by a double septum, which forms the walls of the olfactory prolongation of the brain.

The bones which form the jaws may conveniently be considered together. They are somewhat differently arranged in fishes to their condition in other animals, but the bones are still easily identified by the same names; thus pterygoid, palatine, maxillary, and pre-maxillary still mark the order of succession of the bones of the palate from behind forward. The palatine bones unite in front with the maxillary, pre-frontal bone, and vomer, though in some fishes certain of the attachments are made by ligaments. The palatine usually forms the roof of the mouth as well as the floor of the orbit, and is always short and broad in the fishes with broad heads and small mouths, and long and slender in the fishes with wide mouths. The presence or absence of teeth on the palatine bone furnishes an excellent character for distinguishing many genera. The maxillary bone is usually small and toothless, and lies between the palatine bone behind and the pre-maxillary in front. In shape it is usually like the pre-maxillary, but more slender. In the Salmon tribe it unites with the hinder end of the pre-maxillary, which is short, and carries teeth along its margin. This condition also occurs in the Herring family, while in the Plectognathi, or Globe-fishes, the maxillary and pre-maxillary are blended into one bone. In the genus Lepidosteus these bones, although forming a single toothed border to the upper jaw, are subdivided into several bony pieces, but in the genus Polypterus the maxillary shows no signs of subdivision. This bone is very small in the Siluroid fishes, and both it and the pre-maxillary are entirely wanting in some of the Eels. The pre-maxillary bones are usually movably connected together at their anterior ends, but in the genus Diodon they are completely blended. The blended pre-maxillaries form the sword-like weapon in front of the snout carried by the Sword-fish (*Xiphias*) and by the Gar-pike. The pterygoid and transverse bones are not always present, though they occur in the majority of fishes. In the Salmon tribe and Eels they are blended with the palatine, and in some other fishes, like the genera Lophius and Synodon, they are entirely absent. Both these bones sometimes support teeth. The mandible, or lower jaw, is sometimes united in the median line in front by bony union, but sometimes the union is made by ligament. In front there is a bone which carries the teeth, called the dentary bone. This usually contains within it a cartilage, which is known as Meckel's cartilage, and the other bones placed behind the dentary are arranged around this cartilage. The lower jaw, however, joins the skull in osseous fishes in a way that is quite unparalleled among other animals. There is a distinct arch formed by a series of bones, which supports both the mandible and the gill-cover, and this arch is prolonged up the sides of the head, so as to unite with its side in the auditory region. The mandibular arch, however, is not altogether distinct from another arch placed behind it, which is termed the hyoid arch, and corresponds with the bones which in higher animals are connected with the tongue. The several portions of the hyoid have received

distinct names: first there is the basi-hyal in the middle, and from this a bone termed the glosso-hyal usually extends into the substance of the tongue. At the sides rise up the long horn-like bones termed cerato-hyal, above this is the epi-hyal, and yet higher still the stylo-hyal. All these tracts are not universally met with. In the Conger Eel, for instance, stylo-hyal is a ligament, and the basi-hyal is blended with the cerato-hyal. In other fishes, like the genus Muræenophis, the glosso-hyal is wanting. From the hinder margin of the cerato-hyal and epi-hyal a number of slender, long, curved bones are prolonged backward and outward. These are termed the branchiostegal rays. They support the membrane which forms the external cover to the chamber which contains the gills. Their number is very variable, but most usually seven, as in the Cod. In the Herrings of the genus Elops there are more than thirty rays in each gill-cover. In the Carp they are flat and broad, and reduced to three in number. In the Angler they are enormously long. Behind the hyoid arch, and more or less connected with it, are the branchial arches. Originally there were six of these arches, one behind the other, with clefts between them, but only five are commonly developed. The first four support the gills, the fifth, margined with teeth, guards the entrance to the gullet. The lower ends of these arches are united to a chain of little bones prolonged backward from the basi-hyal element of the hyoid. This part, usually termed basi-branchial, most frequently consists of three bones. Each branchial arch rises from this outward and upward. It consists of three or four separate pieces of bone, though the fifth arch commonly consists of one bone only. Sometimes these arches become complicated in fishes which live long out of water, such as the Climbing Perch, by developing at their upper margins large bony folds, in the recesses of which water is contained, so that it may trickle from them over the gills. Occasionally the branchial arches remain cartilaginous, and all six pairs retain the cartilaginous condition in Lepidosiren, but the second and third arches do not support gills, though they are found on the last arch. The scapular arch of the fish is often attached to the side of the skull, or occasionally to the basi-occipital, though in the cartilaginous fishes it is usually removed farther back. It consists of several bones, which have received different names from the several anatomists who have described them. In Professor Owen's system the uppermost piece is the supra-scapula, which sometimes consists of two short columnar bones attached to the auditory region of the skull. The next piece is termed the scapula, and these two bones are always blended together in the Siluroid fishes. The lower bone Professor Owen terms the coracoid. They are sometimes blended together at their lower margins, but more frequently these bones are joined by ligament, though in the Siluroids they unite by a toothed suture. The bones which Owen names scapula and supra-scapula Huxley, with good reason, calls clavicle and supra-clavicle. The scapula and coracoid in all animals form the arch which gives attachment to the base of the limb. These bones support and defend the heart in all fishes, and give attachment to the diaphragm which separates the cardiac cavity from the abdominal cavity. They also furnish a margin against which the operculum shuts, enclosing the cavity which contains the gills.

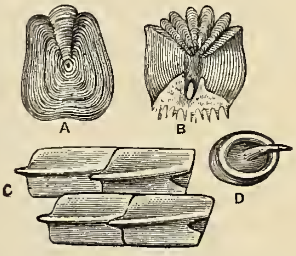
The vertebræ in fishes present many curious modifications. Thus, in the Sturgeon the first five or six neural arches are blended together so as to form a sheath of cartilage which incloses the spinal cord and the front part of the motochord, the tapering end of which is prolonged into the base of the skull. The ribs are attached only to about the first twelve of the trunk vertebræ. They join the vertebræ by simple heads, and often consist of two or three jointed pieces. The same kind of union of the earlier dorsal vertebræ into a continuous cartilaginous sheath around the notochord is formed by the first ten vertebræ of the Chimæroids. In some of the Sharks the ribs become very numerous, extending in Acanthias to forty pairs. Among the Skates of the genus Rhinobatis, Professor Owen finds but a single arch over the bodies of two vertebræ, and in the Chimæra the slender rings which represent the bodies of the vertebræ in the cartilage covering the notochord are more numerous than the neural arches which extend over them. In the Blue Sharks the vertebræ are most perfectly ossified, having only four notches for the neural arch and transverse processes. In most bony fishes the vertebræ are conically cupped at both ends; often the body of the vertebra remains distinct from the neural arch. In most animals the front of a vertebra is easily recognised by the processes called zygapophyses, which yoke the bones together in front and behind, the articular surfaces in front always being directed upward or inward, but in the Perch the reverse condition is met with. The posterior zygapophysis here looks upward, and receives upon its surface the

overlapping anterior process of the next succeeding vertebra. The transverse processes are short in the Salmon and Herring, but very long in the Cod family. As these transverse processes approach the tail they bend down and form a canal which arches over the blood-vessels in exactly the same way as the neural arch protects the spinal cord. The ribs of fishes sometimes articulate with the ends of the transverse processes, occasionally beneath them, and sometimes behind them, but the ribs are not united to a sternum, as is the case in the higher Vertebrata. A considerable number of fishes, such as Globe-fish, Sun-fish, and Pipe-fish have no traces of ribs. The most singular example of vertebræ becoming blended together is seen in the neck of the Pipe-fish (*Fistularia*), in which four neck vertebræ are united into a mass like the sacrum in birds. A true sacrum, however, occasionally exists, as in the Turbot, where two vertebræ are blended together, and in other fishes, like the genus Loricaria, a longer sacrum is developed. The number of vertebræ in osseous fishes is smaller than in the cartilaginous fishes. In the genus Gymnotus, however, there are 236, but in the Sun-fish Professor Owen enumerates only eight abdominal vertebræ, and eight in the tail. In the American bony Pike the vertebræ have the bodies convex in front and concave behind, but no fish is known in which the reverse condition of the cup in front and ball behind is met with. Often in fossil fishes the bodies of the vertebræ are unossified, while the neural arches are well developed. Then the notochord is said to be persistent, and occasionally it is sheathed in rings of bone.

The muscles of fishes are arranged on each side of the body in a series of successive flakes, which correspond in number with the vertebræ. Each of these flakes is attached by its inner border to the corresponding region of the skeleton and by its outer border to the skin. Each muscle or flake is contained in a sheath of connective tissue, which dissolves when the fish is boiled, so that the flakes then readily separate. The fibres of each muscle-flake run straight and nearly horizontally from one partition to the next, so that they extend longitudinally in the length of the fish. In the tail especially these muscles overlap each other, so as to present the same conical form at their ends as is seen in the tails of Crocodiles and Lizards. There are longitudinal divisions of the muscles in most osseous fishes which correspond more or less closely with those observed in the fish-like Batrachia and Ophidia. Towards the head these muscles become specially modified. Both the jaws in fishes are movable as a rule; and the large square muscle which draws the mandible backward stretches from the tympanic region to the maxillary bone, and by another branch to the coronoid process of the lower jaw. This muscle tends to open the fish's mouth. Other muscles widen the back of the mouth, and contract the branchial cavity. There is a series of muscles attached to the hyoid apparatus and the opercular bones by which the requisite muscular movements necessary to respiration are brought about. The branchial arches are similarly supplied with muscles. The muscles of the pectoral fin are arranged in two layers on each side; the fibres run in opposite directions, so as to cross each other. The inner pair retracts the fin, drawing it back so as to touch the side of the body. The outer pair extends the fin or moves it in the opposite direction. Then there are special muscles for depressing and raising the fin. Similar muscles control the ventral fins. Muscular fibres act upon the rays, and there are muscles to expand the rays and move the fins in the various directions which they are capable of taking. The median fins have three or four pairs of small muscles attached to each ray, and by these the rays are elevated and depressed. The caudal fin is moved by three series of muscles, but the variations in the muscular system of fishes are extremely numerous. The sucker of the mouth of the Lamprey is worked partly by a circular muscle, termed a sphincter, like that which closes the mouth or the eye in man, and partly by a series of muscles connected with the hyoid cartilage and with the lateral muscles of the body. The Trunk-fish, which is sheathed in bone, and is therefore incapable of lateral movement, has the longitudinal muscles of the body reduced to a thin layer. The muscles attain their greatest development among the Sharks. In fishes the substance of the muscle is usually colourless, owing to the small quantity of body which it contains; but in some Sharks and the Sturgeon the muscles of the pectoral fins and the caudal extremity are deeply coloured, and nearly all the muscles of the Tunny are red, like those of mammals. The orange-red colour of the flesh in the Salmon and Charr is not due so much to the colour of the blood as to a peculiar oil which exists in the sheaths of the muscular fibres.

The skin is tightly stretched over the body in fishes, and enjoys but little sensibility, through being, for the most part, clothed with scales. In the Lamprey the skin consists of two layers, with

flattened fibres running at right angles to each other; the outer layer, or epidermis, is full of large star-shaped pigment cells, but devoid of scales. The Eel has a soft and thick epidermis. Below the pigment layer are the narrow oblong scales, which are formed of a finely reticulate cartilage. In the genus of Blennies named Zoarces there are circular depressions over the skin, due to minute round scales embedded in the dermis. Most osseous fishes possess flexible scales, marked with either concentric or radiating lines, or both combined. In these scales there is usually a nucleus, which may be irregular. The radiating lines diverge from the circumference of this nucleus. These lines are very numerous in the scales of the Loach (*Cobitis*). The parts of the margin of the scale between the radiating lines usually project in little convexities, and when the irregularities are limited to one end of the scale that end of the scale is usually implanted in the skin. In many fishes the free end of the scale is bordered with tooth-like processes. The surface of the body in most fishes is lubricated with a thin layer of mucus, but in the Eel and Tench the mucous layer is thick. This fluid is secreted by a canal which extends along the body, and has many ramifications among the bones of the head, where it exudes through pores upon the cranium, face, jaws, pre-operculum, and through tubes which perforate the scales along what is called the lateral line, usually distinguished on the sides of the fish by a lighter or darker colour. Rymer Jones remarks that after a fish has been dried in a napkin it soon becomes covered again with mucus, which issues from the pores. In the Tunny (*Thynnus thynnus*), there may be seen beneath the skin, running the entire length of the lateral line, a glandular organ, from which the little tubes are given off to the lateral line. The mucous system, however, is best developed in the Rays. In the genus Acanthoclinus there are several lateral canals which give off short tubes, which tunnel a way through the scales as they pass onward. Professor Owen remarks that the silvery and golden lustre of fishes is mostly on the surface of the scales. The silvery pigment known in commerce under the name of argentine consists of very minute crystals of various earthy substances scraped from the scales, which often also occur upon some of the internal organs. The blue, red, green, and other bright colours of fishes are usually due to coloured oils, which occupy cavities in the skin, and are capable of changing their position, so as to alter the colour of the fish under the influence of excitement, or in harmony with the colour of the sea-bed upon which the fish is living. Many fishes change colour after death.



SCALES OF FISH.
A, Cycloid; B, Ctenoid; C, Ganoid; D, Placoid.

The scales of fishes consist of two layers. The lower layer resembles the fibro-cartilage of the human body, while the upper layer contains cartilage cells similar to those which are seen in the bluish cartilage covering a joint. The parts of a scale are defined in relation to the nucleus or focus from which growth originates. The longitudinal lines which run out from this nucleus sometimes form furrows and sometimes perfectly closed tubes. The broad plates which form the armour of the Pipe-fish are penetrated by canals, which all converge from the margins towards the middle of the scale. The concentric lines of scales are found to originate in the development of new cells, which become filled with horny matter, and ultimately arrange themselves in concentric lines. Scales show, when examined with the microscope, corpuscles, which are similar to those seen in bone. The fibrous layer of the scale may easily be found by scraping off the external cellular lines and corpuscles, when the fibres of the lower layer will be seen to cross each other at various angles. The growth of the spines upon scales appears to be similar to the growth of teeth, for each spine is contained in a distinct capsule or envelope. When the capsule is opened the spine can be easily removed from it, but as the germ develops it acquires roots, and comes to consist of several layers. The late Professor Agassiz, impressed with the differences of form in the scales, at one time believed that fishes might be classified by means of them, and he proposed to divide the scales into four types: those which were bony, and formed of a thick osseous layer, covered with hard transparent enamel, as in the genera Lepidosteus and Polypterus, were termed Ganoids; those dermal spines or tubercles seen in the Thornback and many other cartilaginous fishes, which have a spine arising from a more or less circular bony base, were called Placoid scales; the scales which have the free margin more or less comb-shaped were termed Ctenoid; and those marked with a concentric structure were named Cycloid.

To the two latter groups the great multitude of living fishes belong, but in the earlier ages of the earth's history Ganoid fishes were the prevailing types. Hence the older and less perfectly ossified division of fishes has been named by Dr. Günther, Palæichthyes.

The nervous system in fishes presents an unusual amount of variation. In the Skates there is a slight enlargement of the spinal column in the region where the large nerves are given off to the pectoral fins, and the same condition may be noticed in a less degree in the Sharks, but no corresponding enlargement of the spinal cord has been noticed in the Flying-fish or any other osseous fishes. In the Sturgeon there is a slight enlargement of the spinal cord at the beginning of the caudal region; in the Sun-fish the spinal cord is said to be reduced to a short conical appendage to the brain; and in the genera Tetrodon and Diodon the spinal cord is exceedingly short and small, but it has not the ganglionic structure seen in the Sun-fish. But in most fishes the spinal cord is as long as the neural canal. It is often marked by longitudinal fissures along the ventral and dorsal surfaces; and in the Sturgeon there is a less complete lateral groove dividing the spinal cord into dorsal and ventral columns. And in many fishes, such as the Cod and Herring, six cords may be distinguished: two of which are dorsal, and govern sensation; two ventral, and govern motion; and there are also two lateral regions. As the spinal cord approaches the brain it enlarges. According to Professor Owen, fishes are especially distinguished by having lobes which correspond to the great vagus nerve, or pneumogastric, as it is usually called, extending into the fourth ventricle of the brain, which is a cavity at the beginning of the medulla oblongata, or part where the brain becomes connected with the spinal cord.

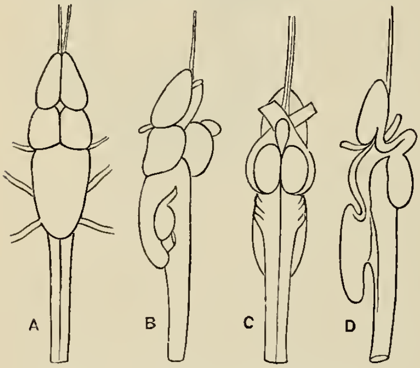


DIAGRAM OF BRAIN OF CODFISH.
A, Upper; B, Side; C, Under; D, Section.

The brain has its parts always arranged one behind the other in longitudinal succession, as among Amphibia and Reptiles. There is a hindermost part, which is single, called the cerebellum, which in most fishes is comparatively small, but becomes large and marked with transverse folds in the Sharks and Rays. Placed in front of this are two more or less rounded or ovate masses of brain, called the optic lobes. Farther still in front is the cerebrum, which usually consists of two masses, which may be larger or smaller than the optic lobes; but among the Sharks and Skates these masses of the brain are usually more or less blended together. In many fishes there are, besides, large olfactory lobes placed in front of the cerebrum, and from these the nerves of smell are prolonged. The nerves are given off from the brain, precisely as in other animals, and the spinal cord prolonged down the vertebral column gives off nerves usually from between the vertebræ, though occasionally, as among some Sharks, they pass through perforations in the bony arches which cover the spinal cord.

In most osseous fishes the cerebellum is smooth and convex; it is frequently hemispherical, as in Amblyopsis, a genus of blind fish. In the Eel it is transversely elliptical; in Lepidosteus it is longitudinally elliptical; it is oblong in the genus Diodon; it is a depressed tongue-shaped body in the Cod; it is pyramidal in the Perch, and attains an immense development in the Sharks, where it extends over the optic lobes, which is also the case in the genus Amblyopsis; while in the Saw-fish it extends forward so far as to rest upon the cerebrum. It is largest in the most active fishes, is very small in the Lump-fish, is unsymmetrical in some of the flat fish, has a longitudinal groove in the genus Diodon, and is transversely divided in the genus Lophius. The fishes in which it shows the branching interior structure called the "arbor vitæ," due to the grey matter being folded over the white nervous matter, are Sharks and the Tunny. Another peculiarity of the Skate tribe, and found in most of the allied fishes, is the development of large convoluted lobes at the sides of the medulla oblongata, in the position where the fifth nerve is given off, a condition well seen in the Torpedo and in the Chimæra monstrosa. The optic lobes are usually the largest portion of the fish brain; they are spheroidal. Prolonged downward from this region is that remarkable part of the brain called the pituitary body, and upward the pineal gland is given off in front. There is a cavity in the optic lobes, which is one of the ventricles. It is quite exceptional for the optic lobes to be smaller

than the cerebral lobes of the brain, as they are in the genera Polypterus and Lepidosiren. In the Blind Fish (*Amblyopsis*) the optic lobes are exceedingly small. In several fishes, such as the Sturgeon, the optic lobes are almost completely united into one mass, but even where they are most widely separated, as in the Perch and the Herring, they are connected by a transverse band which passes in front of the third ventricle. The cerebral hemispheres often have a pinkish appearance, and the nervous matter is fissured and sometimes nodulated, but never approaches the convolute character seen in the higher mammals. These nervous masses are large, smooth, and elongated in many fishes, and in the Sharks become blended together; but in the bony fishes the cerebrum is proportionately small, especially in the Herring. It is also small in the Perch and Bream, but is relatively largest in the Ganoid fishes, which have hemispheres exceptionally large. The cerebral lobes are usually solid, but sometimes contain a lateral ventricle. The olfactory lobes are two distinct masses of grey nervous matter, which are never united by a transverse band, and may be in contact with each other in front of the cerebrum or widely separated. The true olfactory nerve consists of a group of distinct fibres, where it is given off from the olfactory lobe of the brain. The cerebral hemispheres of fishes correspond to that portion of the brain in mammals known as the corpora striata.

The relative size of the brain to the body may be gathered from the fact that in a Carp weighing 11,280 grains the brain weighed fourteen grains. As with higher animals, the brain acquires its full size before the fish has attained its full growth, and hence is relatively smaller in old fishes than in young ones. The great development of the medulla oblongata in fishes has a direct relation to the large size of the respiratory organs, or gills. The development of the cerebellum, so remarkably seen in the Sharks and Rays, is connected with active locomotion. Professor Owen observes that there is a distinct relation between the form of the brain and the habits of the fish, but all fishes of the same habit have not the same types of brain. "Thus the Shark and Pike are ferocious and predatory, the Angler and Skate are crafty, the Sword-fish and Stickleback love fighting, and the Barbel and Carp are timid, peaceful browsers. If the cerebral hemispheres of the Shark and Pike are compared, these parts of the brain differ more in shape, size, and structure than in any other fishes, though they are equally sanguinary, equally insatiable, both unsociable, and are tyrants, one of the sea and the other of the lake. The cerebrum of the Pike is smaller than the cerebellum; in the Shark it is larger than all the rest of the brain. In the Pike the two lobes are distinct, and united only by a narrow transverse band, but in the Shark they are blended into one large globular mass. In the Pike the cerebral lobes are narrow, but in the Carp it feeds upon they are broad, and in the fighting Stickleback the cerebral hemispheres are longer and narrower than in the cowardly Gudgeon."

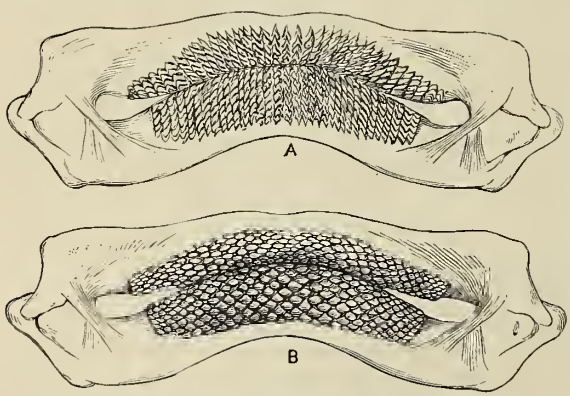
The organ of smell in fishes has no connection with the mouth, and is in no way connected with respiration, as in higher animals. In the Lamprey and Hag (*Myxine*) it is single, but in all other fishes there are two olfactory organs. In osseous fishes these organs are placed at the sides of the snout. The Wrasses have a single opening for each nose sac, but in many fishes there are two, and then the anterior one is closed by a valve or circular muscle, and the posterior one is open. In the Sharks and Skates the nasal cavities are on the under side of the snout, and here the single wide opening is defended by a valve. The organs of sight in fishes are marked by a few peculiarities; thus, there is no lachrymal gland, the eyes apparently being sufficiently moistened by contact with the water. In the Hag and some other fishes the eye is a mere speck coated with dark pigment, but, as a rule, in osseous fishes the eyes are large, and are especially conspicuous in the Sun-fish. The crystalline lens is large and firm; the fibres which form it usually converge to two poles, like the meridians on a globe, but in the Salmon tribe and Sharks they converge to a line on each side. It was found by Sir David Brewster that the fibres of the crystalline lens in the Cod are locked together by teeth, like those on cog-wheels. He calculated that in the eyes of a Cod there are five millions of fibres, on which there are sixty-two thousand five hundred millions of these teeth, and yet in the living animal the organ is perfectly transparent. The pupil of the eye is usually round, but in many Sharks it is elliptical, and in the genus Galeus it is four-sided. In the Skates and flat fish a remarkable fringed process is connected with the upper margin of the pupil, and is capable of being let down and drawn up like a curtain, to regulate the quantity of light admitted to the eye. This would seem an arrangement to supplement the feeble contraction of the iris in fishes. In the Sharks and Sun-fish the eye is contained

in a hollow cartilaginous sheath, but usually the sheath is formed of two hemispherical cups, which are sometimes cartilaginous and sometimes bony. There is often a good deal of fat between the outer sclerotic layer and the more vital internal parts of the eye. In the fresh-water genus Anableps the cornea is divided by an opaque horizontal line, on each side of which the iris is perforated by a pupil. The muscles which move the eyes of fishes correspond with those of man, and are usually six in number.

The organ of hearing is well developed in all fishes; the membranous labyrinth in the Lamprey has only two semicircular canals, and in the Myxine there is only one of these canals, but in all other fishes there are three, as in higher animals; they communicate with a vestibule, in which are contained the bony plates called otolites; there are usually two of these flattened, somewhat oval organs, and one is larger than the other. But in a good many fishes, such as the Plectognathi and Lophobranchiates, the otolites are represented by calcareous dust. No fish possesses a cochlea or a true tympanic membrane, but sometimes there is a connection between the labyrinth of the ear and the air-bladder, made by a chain of small bones. In the Loach the air-bladder is exceedingly small, extending under only two vertebræ, and is united with the head in this way. The external ears in the Skate are on the top of the head.

Closely allied to the organs of sense must be classed the electric organs of fishes, though the electric faculty is developed in very few genera. The best known of these are the Torpedo and the Electric Eel (*Gymnotus*), though less powerful electric organs exist in various species of Malapterurus, and are said to exist in Trichiurus, Gymnarchus, and a species of Tetrodon. In the Torpedo there are two electric organs; in the Electric Gymnotus there are two on each side of the body, where they occupy almost the whole of the lower half of the trunk, and are arranged on the upper and lower sides of the body. The electric organs are relatively larger in the Gymnotus, but their electric power is less. In the Malapterurus electricus the electric organ lies beneath the skin, and invests the whole body, with the exception of the head and fins. The electric organ is here divided into minute lozenge-shaped cells, so that the fish is protected by an electric coat, but the shock from it is comparatively feeble. In the genus Mormyrus a gelatinous organ placed on each side of the tail was formerly believed to be electric.

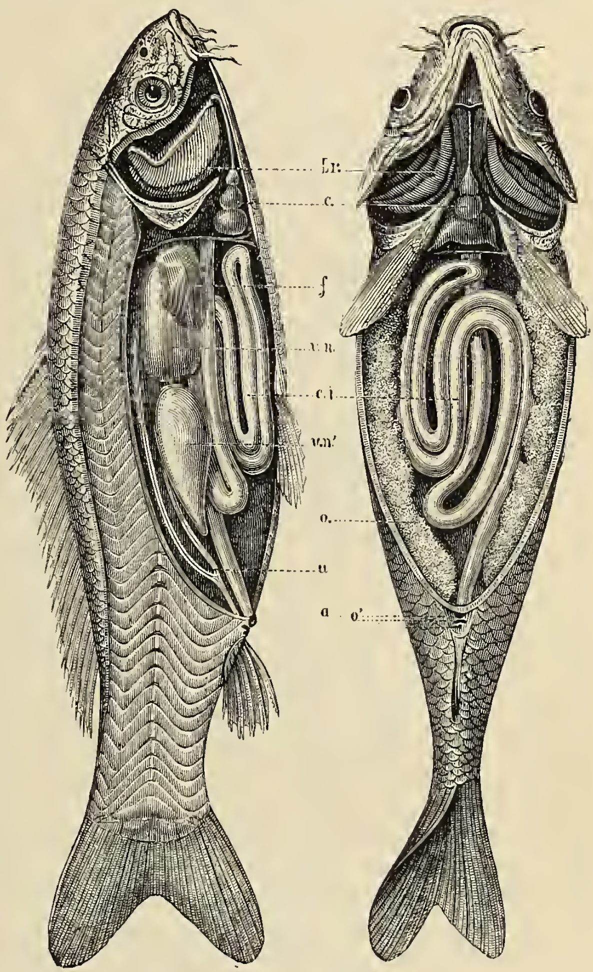
The teeth of fishes present a remarkable variety in their forms and numbers. Professor Owen remarks that the Lophobranchii are toothless, as are the Sturgeon, the Paddle-fish, and Ammocetes, which is the larval form of the Lamprey, requiring four years for its development. The Myxine has a single-pointed tooth in the roof of the mouth, and two serrated dental plates upon the tongue. The Tench has one grinding-tooth on the occiput, opposed to which are two jaws in the pharynx below which bear teeth. In the genus Chimæra the teeth in the maxillary bones are confluent into two pairs, and there are two teeth in the mandible, but in the Siluroids and many other fishes the mouth is crowded with teeth. A large number of fishes have conical teeth; several of the Rays, like Myliobates, have the teeth arranged like a tesselated pavement. In the genus Citharinus the teeth bifurcate at their extremities; in the genus Platax they divide into three points. Sometimes there are hemispherical teeth arranged like a pavement, as in the Wrasse. The rarest position for teeth in a fish is upon the maxillary bone, though they are developed there in Salmon and Herrings, and some Ganoids. In many fishes the teeth are blended with the jaw; in Sharks their broad bases are usually attached by ligament; in the remarkable snout of the Saw-fish organs like teeth are implanted in sockets. Sometimes, as in the Wolf-fish (*Anarrhichas*), the front teeth are adapted for grasping shells, while the back teeth are fitted for crushing them. In all fishes the teeth are shed and renewed many times during the



JAWS OF MALE (A) AND OF FEMALE (B) SKATE.

whole duration of their lives; the only teeth which are retained permanently being those in the rostrum of Pristis, the dental masses of Chimæra, and a few others.

The lips of fishes are not much developed; in Sharks and Rays they are supported by cartilages. In the Cod there are fringed filaments between the lips and the teeth, and in several fishes there are tentacles attached to the lips, which assist in selecting food. There are no proper salivary glands in fishes, and the tonsils are entirely absent. The alimentary canal is usually short and large; in the genus Lepidosiren it is almost straight. The front part, termed the œsophagus, is a funnel-shaped canal coated with a strong muscular substance, so that it grasps the food and passes it downward into the stomach. In many fishes the pneumatic duct from the air-bladder opens into the œsophagus, and in the Ganoid fishes the entrance to this canal is controlled by muscles. The stomach is usually a large simple cavity, with a capacious inlet and a small outlet. Professor Owen defines two kinds of stomach in fishes: first, the enlarged bent tube seen in the Cod, Salmon, Tench, Sturgeon, and most Sharks; and secondly, the form seen in the Perch, Gurnards, Smelts, Pike, Herring, Sprat, and Eel, in which the stomach forms a sort of pouch. It is rare for the stomach to be globular, but this condition is seen in the genus Mormyrus. The stomach takes on some of the characters of a gizzard, and in several fishes this organ is more or less divided into two or three chambers. The juice secreted by this organ has a rapid action on food, and it sometimes happens that the part of an animal contained in the stomach is dissolved, while the part which remained in the œsophagus is entire. Fishes disgorge the indigestible part of their food, and when caught frequently eject the animals they have swallowed. The intestine beyond the stomach is often short and simple. Round its commencement in most osseous fishes there are a number of slender pouches, which represent the sweetbread or pancreas of higher animals, but in the Lamprey and Hag there is no trace of a pancreas, and in a few fishes there is only a single filament to represent it; in the Turbot there are but two, and in the Perch three; in the Sprat there are as many as nine, but in the Salmon they are more numerous, and extend along the whole length of the first part of the small intestine, which is technically called the duodenum. In the Whiting this organ forms a fringe like a collar around the beginning of the intestine, and in the Sturgeon the pancreas becomes more compact, and pours its secretion into the intestine by a single wide duct. Sometimes the pancreas is heavier than the liver.



INTERNAL ANATOMY OF THE CARP.

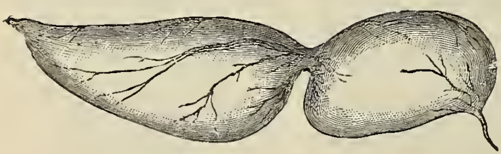
br, Branchiæ, or Gills; *c*, Heart; *f*, Liver; *vn. vn'*, Swimming Bladder; *ci*, Intestinal Canal; *o*, Ovaries; *u*, Urethra; *a*, Anus; *o'*, Oviduct.

The liver in fishes is generally large, and consists of two lobes; it is soft, and usually yellowish-brown, but varies in colour in different fishes, being sometimes white, yellow, orange, green, bright red, and occasionally nearly black. It is an organ in which much of the oil of the body becomes accumulated, though fat fishes have very little oil in the liver. The liver varies in form with the shape of the body, being broad in the Rays and long in the Eels. It is greatly divided in the Tunny.

As a rule, there is a gall-bladder, but it is frequently absent; it is very small in the Rays, and is sometimes entirely separated from the liver, as in Lophius. The bile enters the small intestine near the stomach. The internal surface of the small intestine is usually smooth, but in the Herring it shows slight transverse folds, in the Sturgeon it is divided up into cells, and in the Sun-fish it is lined with little tubes called villi, which absorb the nutriment from the food. The large intestine is straight, and in the Ganoid fishes, Mud-fishes, Sharks, and Rays terminates in a remarkable spiral coil. Though the small intestine is coiled up spirally in the Sword-fish, the coils are not in contact, but in the cartilaginous fishes there is usually a spiral channel which winds around many times. In the Fox Shark there are thirty-four of these turns; at the end of the intestine the membrane lining the valve is deeply honey-combed. Evidence of its existence in fossil fishes is found in the spirally-formed coprolites or petrified fæces which are met with in many of the geological formations.

The organs for purifying the blood, by separating from it the waste products, are different from the kidneys of higher animals, and correspond to organs which exist only in the embryo, and are known to anatomists as Wolffian bodies. Their function, however, is the same in fishes as that of kidneys in other animals. In most bony fishes the kidneys are long and narrow, and extend along the abdomen firmly attached to the vertebræ. The tissue forming them is usually of a reddish tinge; it is soft and spongy, and supplied with arteries from the abdominal aorta, which form the minute globular secreting organs termed Malpighian capsules, similar to those which abound in the outer layer of the kidney in higher vertebrates. Sometimes two ureters lead from the kidney and enter a urinary bladder, but occasionally, as in the Herring, there is only one ureter, and in this and several other fishes the bladder is wanting. It is largest in those fishes in which the air-bladder does not exist. The kidneys are long and narrow in the Ganoid fishes, and compact and generally lobulated in the cartilaginous fishes.

The air-bladder is found in most osseous fishes; it extends along the back of the abdomen, below the kidneys, and is prolonged in some fishes below the caudal vertebræ, nearly to the end of the tail. Its varieties of form are very singular: it is sometimes divided lengthwise into two bladders, but much more frequently divided crosswise into two compartments which communicate with each other. In the Siluroid fish Pangasius the air-bladder is said to be divided into four portions longitudinally. Sometimes the air-bladder develops blind processes: in certain cases from the fore part, in others from the hind part, and occasionally from both ends. In the family Sciænidæ the air-bladder often has numerous lateral branches which themselves ramify into digit-like processes. In some species of the genus Gadus processes given off from the air-bladder line excavations in the transverse processes of the abdominal vertebræ, thus, as Professor Owen has pointed out, foreshadowing the pneumatic condition of the bones in birds. In other fishes—such as Callichthys lucida—the air-bladder is even more singularly developed, since its many branches form a covering round the abdominal viscera. The wall of the air-bladder is often shining and silvery; occasionally the interior is subdivided into small cells: this condition may be seen in the genera Erythrinus and Amia. The air-bladder here seems to be taking on some of the characters of a lung, and in Lepidosiren and Ceratodus the transition is completed. The air-bladder is entirely wanting in the Sharks, Rays, Chimæra, Lampreys, Flat-fish, and other forms, several of which, like the Angler, live habitually at the bottom of the sea. The duct connecting the air-bladder with the œsophagus seems to be the rudiment of the trachea, though it does not always open into the anterior end of the air-bladder. In most fresh-water fishes the air-bladder is filled chiefly with nitrogen gas, mixed with a little oxygen, while in sea fishes the gas is chiefly oxygen, with a little nitrogen. Occasionally, when fishes are brought up from great depths, the air-bladder expands, and forces the internal organs out of the mouth. In the Gurnards the air-bladder assists in the production of sound, so that these fishes may be said to possess a voice.


SWIMMING BLADDER OF CARP.

The blood in fishes is red, but small in quantity. The red blood discs usually have an elliptical shape, and are largest in the Sharks. In the Lamprey the red corpuscles are nearly

circular; there are also, as in higher and lower animals, larger white corpuscles. The greatest quantity of blood is found in the Tunny, which, according to Dr. Davy, is a warm-blooded animal, with a temperature as high as that of most mammals. The lowest type of fish—the Lancelet—has no true heart, but a blood-vessel which pulsates very slowly, there being but one beat in a minute, while in most fishes the number of beats in a minute varies from twenty to twenty-four. The heart is relatively small in all fishes, and even in Sharks and Rays is only about one-thousandth part of the weight of the body, which is about one-half of its relative size in reptiles. This organ in fishes consists chiefly of two parts, which correspond to the pulmonary side only of the heart in man, and are named the auricle and ventricle. It is usually placed in the throat, in a cavity partitioned off by a fixed tendinous diaphragm. The auricle, which is thin and relatively large, receives its blood from a sinus, formed by the union of the veins which bring the blood from the body. Each aperture of the auricle is guarded with strong valves. The ventricle is small and muscular; its form is pyramidal in the Ganoid fishes, lozenge-shaped in the Pike, oval in the genus Lophius. It opens by means of valves into an enlarged muscular portion of the branchial artery, which is called the bulbus arteriosus; this contracts like the ventricle, and assists in forcing the blood into the gills. In the interior of this organ there is an elaborate system of valves, which are arranged in two rows in most Sharks, and form three, or even six, rows in Ganoids. After the blood has passed through the gills the vessels unite and form an artery, which extends under the vertebræ along the length of the body.

The modifications of the gills are sufficiently important to give names to some of the great group of fishes, such as Marsupibranchii, Lophobranchii, and Elasmobranchii. In the Hag, which is an example of the Marsupial type of gill, there are six little branchial sacs on each side; these are produced into short tubes on both sides, and these tubes are prolonged into a longitudinal canal, which extends backward, and carries the stream of water away from the gills on each side, terminating on the ventral surface on each side of a third larger opening, which admits water in the same way into the branchial sacs. In the Lophobranchii, which comprise the Pipe-fishes, the gills, instead of having the comb-like form usual among fishes, form a double series of nearly circular tufts. In the Elasmobranchii the gills are arranged side by side, so as to suggest the idea of plates with openings between them, which are usually long slits, as may be seen in the Sharks and Rays. The branchial chamber is largest in those fishes in which the outlet from it is small. In some of the Eels these outlets approximate close together on the under side of the head; in the Sturgeons and Ganoids there is a canal leading from the fore part of each side of the branchial chamber to the top of the head. These canals are called spiracles. In all the osseous fishes there is only one visible outlet to the gills on each side. Each leaflet of the gills usually consists of a pair of processes, but in some osseous fishes some of the branchial arches support only one series of these leaflets.

Many genera, like Zeus and Polypterus, have on each side three double gills and one uniserial. In the genera Lophius and Diodon there are three bi-serial gills; in Lepidosiren there are bi-serial gills and one uniserial. The number of plates on a single leaflet may range from as few as fifty-five in the Gudgeon to sixteen hundred in the Sturgeon. It is interesting to remark that in the embryonic osseous fish the five interspaces between the hyoid arch and the five branchial arches are exposed on the sides of the head, and that subsequently the branchiostegal appendages are developed, and a single branchial outlet results from the formation and backward growth of the operculum. Owen remarks that the mechanism of breathing in fishes differs from that of swallowing only in the streams of water not entering the gullet, and being diverted to the branchial slits on each side of the pharynx. The bones which cover the gills are collectively known as the operculum. This organ is connected with the skull by means of the hyo-mandibular bone, which also supports the jaws. The principal bone is named the operculum, below which is the sub-operculum, and below this the inter-operculum. In front of these is the pre-operculum.

It is necessary to complete our knowledge of fishes to carefully examine the characters of their fins. In the majority of fishes there are five kinds of fins, which are named pectoral, ventral, anal, dorsal, and caudal (see p. 3). The pectoral and ventral correspond to the arms and legs of higher animals, and when they exist they are always in pairs. The other fins are single or unpaired, and are entirely unrepresented in the skeletons of higher Vertebrates. The pectoral fins are almost always present,

though they are wanting in Lampreys. They are always formed of flexible rays, which are generally branched. The first ray is sometimes strong and spiny, and among Siluroid fishes is barbed on one or both sides. In the Flying-fish, the Tunny family, and the Rays the pectoral fin attains its greatest development, and is usually pointed; but, as Swainson has remarked, families which live in rivers and lakes have the pectoral fins rounded. The Gurnards have the pectorals greatly developed, but their fins are nearly always rounded, though they may be partially cleft or digitate; when broad at the base they usually extend under the throat. The cleft fins are seen in the genus Cephalacanthus; the digitated pectorals are seen in the Gurnards. The pectoral fins of Sharks are generally large. In the flat fish they are smaller than in any other member of the class. In the family Pediculati, or Fish Frogs, the pectoral fins perform the office of feet. The ventral fins are less important in swimming than the pectoral; they are generally of small size, though in the genus Zeus they are larger. In the Eel group they are entirely absent. The position of these fins varies, being placed under the throat in the Star-gazer (*Uranoscopus*), while in the genus Polypterus they are near the base of the caudal fin. When the pectoral is rounded the ventral is usually rounded too, though this correspondence between the fins is by no means universal. Some fishes possess fins which are capable of adhesion by suction. The family Gobiesocidæ has circular concave discs on the breast and belly, which extend between the pectoral and ventral fins. In the genus Regalecus, or Ribbon Fish, the ventral fins have the rays broadened at the extremity so as to resemble oars. The dorsal fin is rarely altogether wanting, though it is absent from Gymnotus branchiurus. The dorsal fin is generally composed of a number of bony rays, placed successively behind each other and connected by a membrane. Frequently there are two dorsal fins. In the soft-finned group the hinder dorsal fin is generally formed of fat. The Polypterus offers a remarkable type of dorsal fin, in that the fin is divided into a large number of finlets, which reach from the head backwards. The dorsal fins are very thick in cartilaginous fishes, and are thinner in the spiny-finned osseous fishes. A few genera have three dorsal fins, as may be seen in the Cods. The rays forming the fin are sometimes slender bones, are sometimes jointed, and sometimes branched. The branched spines are well seen in genera allied to the Mackerel. The common Stickleback furnishes a familiar example of the spiny modification of the fin. Sometimes the dorsal fins are triangular, and sometimes they are broad, and occasionally end in filaments. In a good many fishes, especially among the Eels, the dorsal fin unites with the caudal fin. The anal fin corresponds more or less to the dorsal, only it is placed longitudinally on the inferior margin of the body, behind the vent. Sometimes, as in Gymnotus, it extends nearly the whole length of the fish. The caudal fin is the great organ of motion; it usually consists of two symmetrical lobes, which are made up of a number of radiating rays. The terminal part of the notochord, or spinal column, as the case may be, bends upward, so that a larger number of the fin rays lie below than above it; hence, although the tail in the bony fishes is homocercal in form, it is heterocercal or unsymmetrical in structure. In the Tunny the fin rays are attached to the sides of a somewhat fan-shaped terminal bone, and in these fishes the tail is more deeply forked than in any other. The caudal fin presents every modification in form; it is lanceolate in the Indian Gobies, but is sometimes rounded, or truncate, oblong-oval, even, and variously forked. Occasionally the caudal fin is indistinct; it is but little developed in the Rays, and there is no terminal fin in the Pipe-fish or in Chimæra. In one genus the fin is placed vertically upon the extremity of the tail. The analogy of fins to wings is evidenced by their performing the office of wings in the Flying-fishes. One of the best characters by which the genera and species of fishes may be identified and defined is furnished by the number of rays in the several fins. In most cases these are written in formulæ, in which the number of rays in a fin follows its initial letter.

All fishes have the sexes distinct. The male organs constitute the well-known soft roe, while the ovary of the female is hard roe. In the female the oviduct has its outlet usually in front of the urethra, and behind the anus. In the Californian genus Ditrema the young reach a relatively large size, and are packed in the body of the parent as close as Herrings in a barrel. The oviparous cartilaginous fishes are remarkable for the large size of the egg, and the strength of the case in which it is contained. In Sharks of the genus Cestracion this egg-case is spiral; and in the southern Chimæra it has an oval form with a fringed margin. The males of Chimæroid fishes and Plagiostomes are armed with remarkable organs termed claspers, which are attached to the bases of the ventral fins. A few fishes build nests.

The following sketch of the classification used in this article may be convenient for reference :—

CLASS PISCES.

DIVISION I.—PALÆICHTHYES (FISHES OF ANCIENT TYPES).

ORDER I.—DIPNOI (MUD-FISHES). Family—Sirenoidei.

ORDER II.—GANOIDEI (FISHES WITH BONY SCALES).

Family I.—Amiidæ (North American Mud-fish). II.—Polypteridæ (Nile Pike). III.—Lepidosteidæ (Bony Pike).

ORDER III.—HOLOCEPHALA. Family.—Chimæridæ (Chimæra).

ORDER IV.—PLAGIOSTOMATA (FISHES WITH OBLIQUE MOUTHS).

SUB-ORDER I.—SELACHOIDEI (SHARKS).

Family I.—Carchariidæ (Blue Shark). II.—Lamnidæ (Porbeagle). III.—Rhinodontidæ. IV.—Notidanidæ (Grey Shark). V.—Scylliidæ (Dog-fishes). VI.—Cestraciontidæ (Cestracion). VII.—Spinacidæ (Piked Dog). VIII.—Rhinidæ. IX.—Pristiophoridæ (Shark-like Saw-fish).

SUB-ORDER II.—BATOIDEI (RAYS).

Family I.—Pristidæ (Skate-like Saw-fish). II.—Rhinobatidæ. III.—Torpedinidæ (Electric Rays). IV.—Rajidæ (Skates). V.—Trygonidæ (Sting Rays). VI.—Myliobatidæ (Eagle Ray).

ORDER V.—CHONDROSTEI. Family I.—Acipenseridæ (Sturgeons). II.—Polyodontidæ.

DIVISION II.—TELEOSTEI (BONY FISHES).

ORDER I.—PLECTOGNATHI (FISHES WITH JAWS UNITED).

Family I.—Sclerodermi (File-fish and Trunk-fish). II.—Gymnodontes (Diodon and Sun-fish).

ORDER II.—LOPHOBRANCHII (FISHES WITH TUFTED GILLS).

Family I.—Solenostomidæ. II.—Syngnathinæ (Pipe-fish and Sea-horses).

ORDER III.—ANACANTHINI (SOFT-FINNED FISHES).

SUB-ORDER I.—GADOIDEI.

Family I.—Gadopsidæ. II.—Lycodidæ. III.—Gadidæ (Cod). IV.—Ophiididæ (Sand-eels). V.—Macruridæ. VI.—Ateleopodidæ.

SUB-ORDER II.—PLEURONECTOIDEI.

Family VII.—Pleuronectidæ (Flat Fishes).

ORDER IV.—PHARYNGOGNATHI (FISHES WITH JAWS IN THE THROAT).

Family I.—Pomacentridæ. II.—Labridæ (Wrasse). III.—Embiotocidæ. IV.—Gerridæ. V.—Chromides.

ORDER V.—ACANTHOPTERYGII (SPINY-FINNED FISHES).

Family I.—Percidæ (Perch). II.—Pristipomatidæ. III.—Squamipinnes. IV.—Nandidæ. V.—Mullidæ (Red Mullet). VI.—Sparidæ. VII.—Hoplognathidæ. VIII.—Cirrhitidæ. IX.—Scorpænina. X.—Polycentridæ. XI.—Teuthididæ. XII.—Berycidæ. XIII.—Kurtidæ. XIV.—Polynemidæ. XV.—Sciænidæ. XVI.—Xiphiidæ. XVII.—Trichiuridæ (Star-gazer). XVIII.—Acronuridæ. XIX.—Carangidæ. XX.—Cythina. XXI.—Stromateina. XXII.—Coryphænina. XXIII.—Nomeina. XXIV.—Scombrina. XXV.—Trachinidæ. XXVI.—Malacanthidæ. XXVII.—Batrachidæ. XXVIII.—Pediculati (Sea-devil). XXIX.—Cottina (Gurnards). XXX.—Cataphracti (Armed Bull-head). XXXI.—Comephoridæ. XXXII.—Discoboli (Lump suckers). XXXIII—Gobiidæ. XXXIV.—Oxudercidæ. XXXV.—Cepolidæ. XXXVI.—Trichonotidæ. XXXVII.—Heterolepidina. XXXVIII.—Blenniidæ. XXXIX.—Acanthoclinidæ. XL.—Mastacembelidæ. XLI.—Sphyrænidæ. XLII.—Atherinidæ. XLIII.—Mugilidæ (Grey Mullet). XLIV.—Gasterosteidæ (Sticklebacks). XLV.—Fistularidæ. XLVI.—Centriscidæ. XLVII.—Gobiesocidæ (Suckers). XLVIII.—Psychrolutidæ. XLIX.—Ophiocephalidæ. L.—Labyrinthici (Climbing Perch). LI.—Luciocephalidæ. LII.—Aphredoderidæ. LIII.—Lophotidæ. LIV.—Trachypteridæ. LV.—Notacanthi.

ORDER VI.—PHYSOSTOMI (FISHES WITH THE AIR-BLADDER OPENING INTO THE MOUTH).

Family I.—Siluridæ. II.—Characinidæ. III.—Haplochitonidæ. IV.—Sternoptychidæ. V.—Scopelidæ. VI.—Stomiatidæ. VII.—Salmonidæ (Salmon). VIII.—Percopsidæ. IX.—Galaxidæ. X.—Mormyridæ. XI.—Gymnarchidæ. XII.—Esocidæ (Pike). XIII.—Umbridæ. XIV.—Scombresocidæ. XV.—Cyprinodontidæ. XVI.—Heteropygii. XVII.—Cyprinidæ (Carp). XVIII.—Gonorhynchidæ. XIX.—Hyodontidæ. XX.—Osteoglossidæ. XXI.—Clupeidæ (Herrings). XXII.—Chirocentridæ. XXIII.—Alepocephalidæ. XXIV.—Notopteridæ. XXV.—Halosauridæ. XXVI.—Gymnotidæ (Electric Eel). XXVII.—Symbranchidæ. XXVIII.—Murænidæ (Eels). XXIX.—Pegasidæ.

DIVISION III.—CYCLOSTOMATA (FISHES WITH A CIRCULAR MOUTH).

ORDER.—MARSUPIBRANCHII. Family I.—Petromyzontidæ (Lamprey). II.—Myxinidæ (Hag).

DIVISION IV.—LEPTOCARDII (FISHES WITH A THIN HEART).

ORDER.—PHARYNGOBRANCHII. Family.—Cirrostomi (Lancelet).

CHAPTER II.

THE PALÆICHTHYES, OR FISHES OF ANCIENT TYPES.

DIPNOI, OR MUD-FISHES—Why this Order is Interesting—THE AFRICAN MUD-FISH—THE SOUTH AMERICAN MUD-FISH—THE GENUS CERATODUS—GANOIDEI, OR FISHES WITH BONY SCALES—THE AMIIDÆ—*Amia calva*—THE BONY PIKE OF THE NILE—THE AMERICAN BONY PIKE—Its Remarkable Characters—HOLOCEPHALA—The *Chimæra monstrosa*—The Genus Callorhynchus—PLAGIOSTOMATA—The Sharks and Rays—SELACHOIDEI—THE BLUE SHARK—Its Habits—Muscular Vitality—Economic Uses—Other Genera—The Common British Tope—THE HAMMER-HEADED SHARK—THE SMOOTH HOUND—The Porbeagle, or the Beaumaris Shark—THE THRESHER, OR FOX SHARK—THE BASKING SHARK—Enormous Proportions—The "Sea Serpent"—Habits—Fisheries—Characters—THE SIX-GILLED SHARK—THE DOG FISHES—The Nurse Hound and the Rough Hound—Their Eggs and Egg-purses—"Sea-dog Soup"—The Black-mouthed Dog-fish—Cestracion—THE PICKED DOG-FISH—Why so Named—Characters—Various Forms—THE SPINOUS SHARK—THE MONK-FISH—The Indian Shark Oil Industry—BATOIDEI, THE RAYS—Distinctive Features—THE PRISTIDÆ—THE RHINOBATIDÆ—THE TORPEDINIDÆ—THE GENUS TORPEDO—Strength of the Shock—The Electric Organs—Characters—Other Forms—THE RAYS—Characters—The True Skate—Fishery—THE LONG-NOSED SKATE—THE BORDERED RAY—THE SHAGREEN RAY—THE HOMELYN RAY—THE THORNBACK—THE STING RAYS—Growth of its "Spine"—Various Species—THE EAGLE RAY—THE OX RAY, OR SEA DEVIL—CHONDROSTEI—THE STURGEONS—Characters—Caviare—Fishery—Other Economic Uses—The Common Sturgeon—Article of Diet—The *Acipenser huso*—The Sterlet.

DIVISION I.—PALÆICHTHYES.

ORDER I.—DIPNOI.—MUD-FISHES.

THIS small group of fishes has more than ordinary interest, from the circumstance that it comprises surviving representatives of a large fish fauna, now entirely extinct, which abounded in the early periods of the earth's history. And yet, instead of presenting, as might have been expected, characters of immature or imperfectly-developed forms, these fishes are the only ones which make an appreciable approximation in structure to the Amphibia.

FAMILY SIRENOIDA.

There are only three genera known—*Protopterus*, limited to Africa, *Lepidosiren* to South America, and *Ceratodus* to Australia.

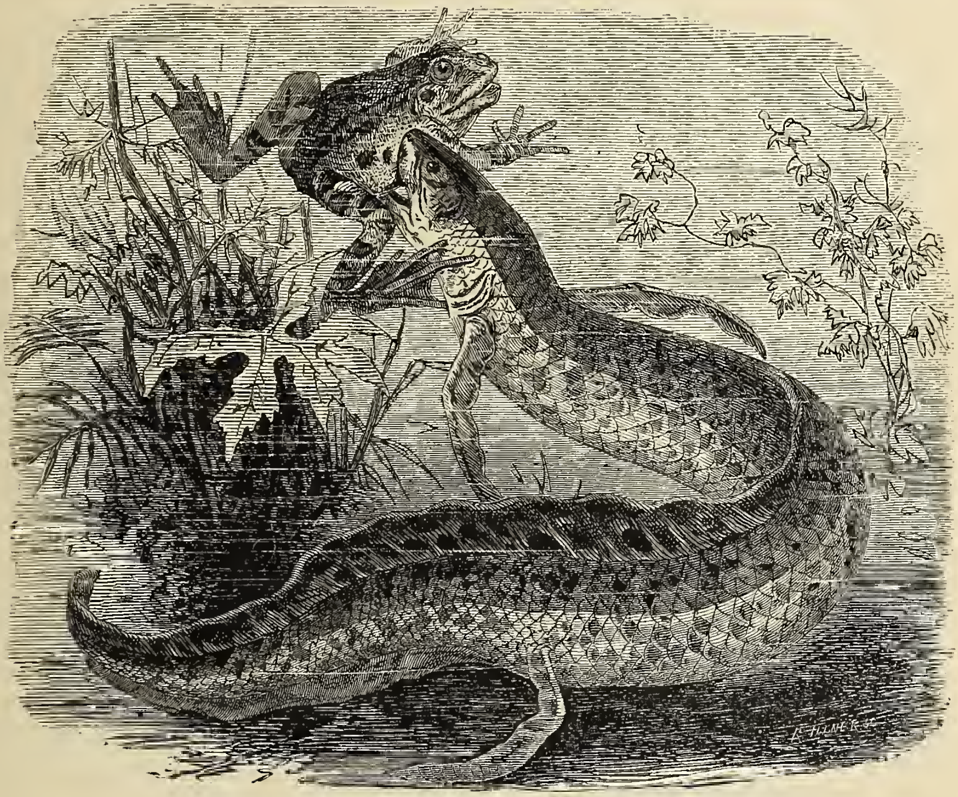
GENUS PROTOPTERUS.—THE AFRICAN MUD-FISH.

But one species is known, the *Protopterus annectans*, which has an Eel-like form, grows to a length of three feet, and is found in the Nile, the Zambesi, and the Gambia. It has been brought alive to this country enclosed in balls of hardened clay, in which the fish hibernate and remain torpid during many months of the year, with a small hole in the clay at each end to admit the air. They are abundant in the rice-fields, where they are dug out of the mud by the natives, who regard them as a delicacy.

The examples originally described by Professor Owen were twelve or thirteen inches long, and measured about four inches and a half round the body. The head was two inches long, and the distance from the pectoral to the ventral fin five inches and a half. The muzzle is blunt, and the head gradually enlarges towards the gill-opening, which is just in front of the base of the pectoral fin or fore-limb. A line of mucous pores surrounds each eye, and from this the lateral line commences, and is prolonged down the body to the end of the tail, making a slight downward curve towards the ventral fins. There is a membranous dorsal fin. The body is sheathed in scales of the cycloid pattern, which are arranged in about sixteen longitudinal series on each side of the body. Each scale is marked by a number of canals, which radiate from a centre near the posterior edge, and are connected by cross canals. The bones are green, like those of the common Gar-fish. The vertebral column retains the primitive condition seen in the early stage of development of all animals in which the continuous cylindrical, somewhat gelatinous rod, which is termed the notochord persists, in the position which usually becomes occupied by the bodies of the vertebræ, a change which is brought about by the deposition within the notochord of the salts of lime which form bony matter. Here the notochord has merely an external sheath of ligament, except towards the tail, where it becomes somewhat cartilaginous. The neural arches, however, which cover the spinal cord, are converted into bone, and are prolonged into neural spines, each of which articulates with a bone above, which bones form the base of the dorsal fin. There are thirty-six pairs of simple ribs, which are all of

about the same length, and all short; they are bent downward in the tail, so as to form an inferior arch like the neural arch, after the manner which is usual in fishes. The skull is penetrated by the cranial end of the notochord, though it there becomes ossified. The skull is divided into distinct cranial segments, each formed of bones. The lower jaw consists of two pieces—a dentary bone in front and the articular bone behind. The jaws are armed with two slender conical teeth on the pre-maxillary bones, and with a strong dental plate on both the lower and upper sides of the mouth. These teeth are marked with ridges, and were originally compared by Professor Owen to the teeth of Ceratodus—then supposed to be extinct—and the teeth of Chimæra. There are no teeth on the bones of the palate.

The intestine is straight and short; it terminates in a spiral valve formed of six gyrations. The



THE AFRICAN MUD FISH.

vent does not open in the middle line of the body. There is no trace of a pancreas or spleen, but the dark-brown liver has a gall-bladder in a notch of its left margin. The bile is conveyed by a duct into the intestine. The brain closely resembles that of Amphibians. This genus is distinguished by possessing six branchial arches with five intervening clefts, and has three small branchial appendages above the small gill-opening. The air-bladder has a longitudinal partition, so as to divide it into two elongated sacs, which are supplied with venous blood from a pulmonary artery. Each of these sacs is divided into cells, which are more numerous in the fore-part of the bladder than in the hinder part. It is by means of these incipient lungs that respiration is carried on during the dry months, when the animals live out of water. Air is introduced directly into the air-bladder, and the opening of the duct from it into the œsophagus is kept distended by a cartilage like a rudimentary larynx. When, in the wet season, the Lepidosiren resumes life as a fish, the branchial circulation again goes on vigorously, but the animal still rises to the surface and swallows air.

The Protopterus exhibits the simplest form of limb which is known. The pectoral and ventral

fins or limb each consists of a single ray which tapers to a point, and is jointed much like a single-jointed fin-ray of an ordinary fish. These limbs are attached to arches which represent, in an imperfect condition, the corresponding pectoral and pelvic girdles of osseous fishes and amphibians.

GENUS LEPIDOSIREN.—THE SOUTH AMERICAN MUD-FISH.

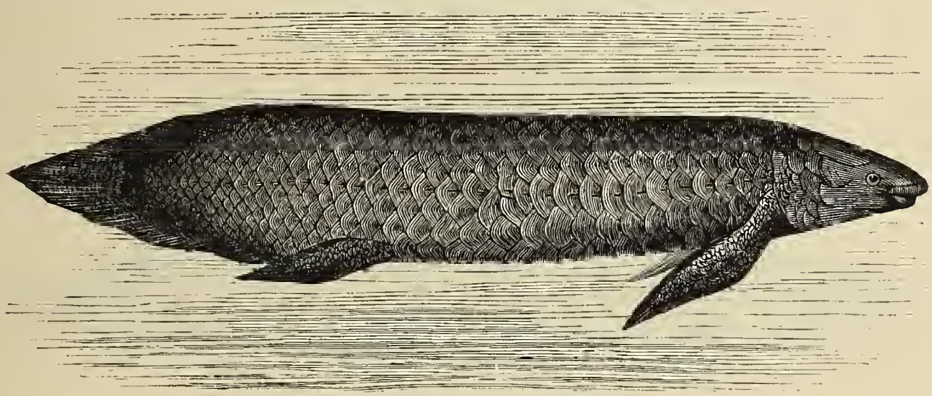
Lepidosiren was discovered in the River Amazon. It so closely resembles Protopterus in the form of its body that for a long time the two species were placed together in the same genus. The *Lepidosiren paradoxa*, however, has but five branchial arches with four intervening clefts, has no trace of the external branchial appendages, has no fringe to the pectoral and ventral filaments, such as is seen in Protopterus, and has about fifty-five pairs of ribs. In this animal the eyes are small, and the skin passes over them. The species reaches a length of three feet, and when the waters dry up on the tributaries of the Amazons the fishes plunge into the mud.

Professor Owen remarks that Lepidosiren is proved to be a fish not by its gills, nor by its air-bladder, nor by its spiral intestine, nor by its unossified skeleton, nor by its extremities, nor by its eyes, nor by its ears, but simply by its nose. For the organ of smell in every fish is a shut sac, communicating only with the external surface; while in every reptile it is a canal with both an external and an internal opening. So that we arrive at the unexpected result that a reptile is not characterised by its lungs, nor a fish by its gills.

THE GENUS CERATODUS.

A few years ago Mr. Gerard Krefft announced that there was still living in the rivers of Queensland, in the north-east of Australia, a fish with teeth which so closely resembled those of the fossil Ceratodus from the older Secondary rocks, that he was compelled to refer it to the same genus. It is stated to occur abundantly in most of the rivers, and is known locally among Europeans as the Flat-head. At night it is believed to leave the streams, and go out among the reeds and rushes on the flats, which are left uncovered at low tide, and it is said often to be heard moving on still nights on the banks of the river Mary. In some localities it goes up the river only as far as the water remains brackish, but other specimens have been captured in fresh water thirty miles inland. Individuals are said sometimes to reach a length of six feet. The intestines are always found crammed full of dead leaves, which belong to the natural orders of plants Myrtaceæ and Graminæ. In external shape the Ceratodus has a close likeness to the Lepidosiren, except that it more nearly resembles an ordinary fish, has stouter paddles, and large scales covering the body. The head is longer than it is wide, but broad and flattened, with a short snout. Its upper surface is covered with a thick skin pierced by small pores. The gill-cover and throat are clothed with scales like those on the body; the eye, which is small, is near to the snout; the corners of the mouth are in front of the eyes, and the lips are thick and soft. The whole body is covered with large scales, which have faint concentric lines of growth, but towards the end of the tail the scales become rapidly smaller, and small scales cover nearly the whole of the terminal fin. The central portions of the fin-paddles are also covered with small scales. The lateral line is marked in the usual way; from the head to the region of the vent there are twenty-two large perforated scales in this line, and beyond that point there are about seventeen smaller scales. In the middle region the body is encircled by eighteen or twenty rows of scales, of which only one-third are above the lateral lines. The limbs, like the tail, vary a good deal in appearance; they taper to a fine point, the front pair being longer than the hinder pair, which latter are given off just in front of the vent. Nearly all the skeleton is cartilaginous, but in some regions of the skull the cartilage is sheathed in thin bony tissue. Dr. Günther describes it as a complete inner cartilaginous capsule, covered with an incomplete outer osseous case, to which some cartilaginous elements are attached. The skeleton of the branchial apparatus is formed of fine arches, and though entirely cartilaginous, is similar to that of ordinary bony fishes. The vertebral column is remarkable for retaining a condition which is usually found only in the early embryonic development of the higher vertebrates, for there is no complete division of the central gelatinous rod called the notochord into separate vertebræ. Upon this notochord are developed about sixty-eight sets of arches, which extend above it to enclose the spinal cord, and below to support the blood-vessels. Twenty-seven of the lower arches behind the head carry ribs. The teeth are fitted for

cutting and crushing. There is one pair of small teeth in the fore-part of the jaw which, from their position upon a bone called the vomer, are termed vomerine teeth; they meet each other at a right angle, which is directed forward. The other teeth are much larger, and are crossed by six strong ridges, which extend inward from the outer margin. Between these ridges are five notches. In a specimen three feet long this tooth is an inch and a quarter long and half an inch wide. The corresponding teeth in the lower jaw have a similar shape, and are so placed as to fit against the others and form an apparatus for grinding food. The hard parts of the fore-limb are entirely cartilaginous; the paddle is joined to the scapular arch by a cartilage which represents the humerus. A median row of cartilages of a quadrate form, twenty-six in number, extends the length of the limb, and on both sides of it rays are given off which diverge downward and outward. This type of fin is quite unparalleled, although the central series of cartilages may be compared to that of the Lepidosiren. Dr. Günther has compared the fin to the tail of an ordinary osseous fish; nor is the plan of structure very dissimilar to the tail of Ceratodus itself. The structure of the hind-limb is quite like that of the fore-limb, except that it is rather more symmetrical and is shorter. The intestine is nearly straight, and below the stomach is traversed throughout by a spiral valve, which may be compared to that of Sharks and Rays, and winds around nine times. But the most remarkable circumstance about this fish is the fact that it can breathe either by gills or by lungs, or simultaneously by both. The gills are not connected with spiracles, nor is there any true operculum. The lung is single, and is a wide sac which extends down the middle of the dorsal region, from one end of the abdominal cavity to the other. It is divided into about thirty compartments on each side, and in these the tissue presents much of the character which is usually seen in the lung of a reptile. It has a short duct terminating in a glottis, which opens on the ventral side of the gullet. The air is probably expelled from the lungs much as among reptiles—by the tissue contracting; and this is thought to account for the grunting noise heard at night when the fish are out of water. The species has been named *Ceratodus Forsteri.*



THE CERATODUS. (*After Günther.*)

ORDER II.—GANOIDEI, OR FISHES WITH BONY SCALES.

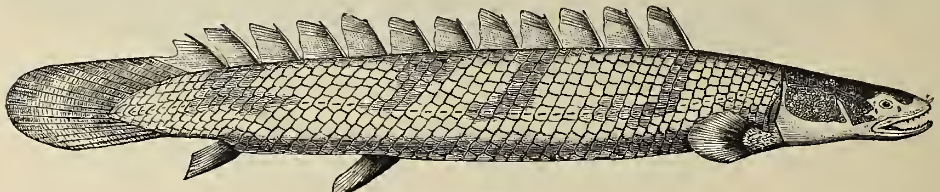
FAMILY I.—AMIIDÆ.—THE NORTH AMERICAN MUD-FISH.

The Ganoid fishes are a group fast verging on extinction, and are represented at the present day by three families, which include four genera and six species; but from the light which their structure throws on the fossil forms of both Primary and Secondary strata, no less than from some remarkable points of structure, they deserve notice. In the first family, Amiidæ, there is but one species—*Amia calva,* which is known as the Bow-fin of Lake Champlain, the Dog-fish of Lake Erie, the Marsh-fish of Canada, and is sometimes known as the Mud-fish. The body is long, compressed behind, and sub-cylindrical. The head is broad, with a short snout; the jaws are margined with an outer series of delicate sharp-pointed teeth, which are closely set, and there are patches of similar teeth on the vomer, palatine, and pterygoid bones. The lower jaw has a single row of

teeth. The tongue is covered with papillæ; the nostrils are prolonged into short tubes. The scales are of the cycloid pattern, and are sometimes covered with enamel; they are large, and marked with radiating lines, and are enveloped in a soft skin; those which occur in the lateral line are slightly elevated. The colour is dull, often dark greenish, with black spots and bands, and there is frequently a round black spot on the tail. The animal is covered with thick mucus. Its movements in the water are not very rapid. It feeds chiefly on fresh-water crustacea, is sometimes eaten by the Indians, and attains a length of about two feet. The vertebral column is chiefly remarkable for having intercalary vertebræ introduced in the tail. The first appears after the sixth caudal, and the last between the twenty-second and twenty-third caudal. These intercalary bones are entirely devoid of processes, and occasionally one or more of them may be absent. The end of the vertebral column is cartilaginous, and directed upward. The air-bladder is a large membranous sac divided anteriorly into two short horns; its internal appearance is compared to that of the lung of a serpent with cells in the anterior part which disappear towards the posterior end. It communicates with the œsophagus by a duct, and has a sort of glottis with an oblong opening. There are four gills; each arch is formed by a double row of leaflets; there are ten or twelve branchiostegal rays. The stomach forms a blind sac, diverging from the intestine; there are no pancreatic appendages; the liver has two lobes; and there is a rudimentary spiral valve at the termination of the intestine. This fish is limited to the fresh waters of the United States, and is especially met with in the great expanse of low-lying country between the Alleghanies and the Rocky Mountains, in the Mississippi, Northern lakes, and Middle States.

FAMILY II.—POLYPTERIDÆ.—THE BONY PIKE OF THE NILE.*

This is the type of a family which at the present day includes only two genera. Polypterus occurs throughout the tropical parts of Africa, especially in the Nile, Gambia, and Senegal rivers, and other parts of the west coast. It is an elongated fish, with a short snout and somewhat cylindrical body. It is defended with lozenge-shaped ganoid scales. The species *Polypterus bichir* lives in the mud at the bottom of the rivers, where the fish crawl or walk like Seals by means of their fins. They swim with great rapidity, much in the manner of serpents. At the time of reproduction they are chiefly at the surface of the water. This fish presents an extraordinary appearance, from the way in which the dorsal fin is broken up into a succession of little finlets, which vary in number in the several varieties from eight to eighteen. The vertebræ are bi-concave, as in ordinary fishes, but the termination of the vertebral column is cartilaginous. The head is covered by enamel similar



THE POLYPTERUS.

to that which defends the scales of the trunk. From the lateral expansion of the bones of the head, this fish presents much the same sort of resemblance to a Chelonian that the head of the Lepidosteus has to that of a Crocodile. The ventral fins are well developed, and the anal fin is placed close to the lower margin of the caudal fin. The central portion of the fin in these fishes is fleshy, and covered with scales, so that the rays appear as a fringe around it. This character is met with in many of the fishes of the Old Red Sandstone, and Professor Huxley has proposed to unite them together under the name of Fringe-finned Fishes, or Crossopterygidæ. There are three bones between the fin-rays and the shoulder-girdle. The air-bladder is more simple than that of Lepidosteus; it consists of two sacs, which are cylindrical and unequal, but there are no internal cells in the bladder representing lung structure. There is, however, a duct from the two lobes opening into the œsophagus, and the opening is defended by a circular muscle. There are three and

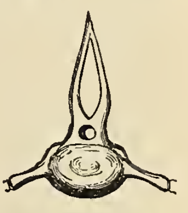
* Genus *Polypterus*.

a-half pairs of gills, but no gill upon the operculum. There is a spiracle on each side of the parietal bone, covered by a bony plate. The branchiostegal rays are replaced by a single plate of bone. The stomach has no blind sac, there is one pancreatic appendage, and the intestine terminates in a spiral valve. There are fifty-one vertebræ in the abdomen and sixteen in the tail.

From Old Calabar there comes a remarkable fish closely allied to the Polypterus, which is named *Calamoichthys Calabaricus*. It has a much more elongated form ; the dorsal and ventral surfaces are parallel. There are about a hundred vertebræ in the abdomen and ten in the tail. The dorsal fin is represented by from nine to eleven finlets ; the ventral fin is absent, and the small anal fin is placed at the hinder extremity of the body, immediately below the tail.

FAMILY III.—LEPIDOSTEIDÆ.—THE AMERICAN BONY PIKE.*

The Bony Pike, or Garfish, as it is often called, is one of the most distinctive of American types of fish-life. It is met with in the rivers and lakes of the basin of the St. Lawrence, in various parts of the United States, and in Mexico, and occurs in Cuba. American authors have distinguished more than twenty different species, which have been referred to several genera. Dr. Günther reduces these species to three—the *Lepidosteus viridis*, the *Lepidosteus platystomus*, and *Lepidosteus osseus*. These fishes swim with the greatest rapidity, darting through the lakes and rivers, and are able to pass through the most rapid currents, not excepting the rapids of Niagara. Their bodies are more flexible than those of ordinary fishes. Agassiz notices that the head moves freely on the neck, and may be indifferently wagged from side to side, or moved upward or down, movements which are impossible in other fishes. This mobility results from the remarkable mode of union of the vertebræ with each other. Instead of being cupped at each end there is a rounded articular surface in front, and a corresponding concavity behind. The vertebral column terminates in a small conical cartilaginous rod, which is directed to the upper margin of the tail, where it is only covered by the skin. The vertebræ have transverse processes, to which the ribs are articulated.



A VERTEBRA OF THE AMERICAN BONY PIKE.

The head has an armoured appearance, and is covered with furrows and rugosities, which are arranged in a definite manner; it is prolonged into jaws, which are large and long in proportion to the size of the hinder part of the head. The lower jaw is always rather shorter than the upper, and is formed of the same bones as occur in the jaws of Crocodiles and Lizards. The maxillaries are a series of bones joined together, end to end, so as to produce by their union a single long bone. The snout includes, besides the maxillaries, long nasal bones and some other bony elements. The fins unite with the skeleton, as in other osseous fishes. The pectoral fins are strongly developed. All the fin-rays are jointed. The air-bladder is placed as in other fishes ; it communicates with the throat by a duct, which is guarded by a circular muscle. This organ is very long, and extends from the œsophagus to the hinder extremity of the body. It is forked in front, but is undivided in the greater part of its length, and sometimes there is a trace of a posterior bifurcation ; it is said to be muscular, so as to be capable of contracting. Its internal surface is cellular, so that it presents some resemblance to the lungs of the lower reptiles and amphibians ; but while air is breathed by this organ there are also gills, which are supported on four arches and have a bi-serial structure. The branchiostegal rays are three in number. The scales, next to the long jaws, are the most striking feature of the animal. They are lozenge-shaped, and arranged in more or less oblique series, so as to overlap each other, and form a close-fitting bony armour. In the middle of the belly the scales are heart-shaped. The external layer of the scales is always brilliant and shining, being formed of enamel, while the lower layer consists of bone. The scales are perforated by canals similar to the blood-vessels in bones, and the vessels passing through them carry blood to the skin. The lateral line is always straight. The colour of the back is brownish-yellow or greenish, sometimes with black spots. The young sometimes have a dark band at the sides, and generally a dark band in the median line of the back. The nasal pores are at the extremity of the snout, and the eyes are a moderate size. These fishes are extremely voracious ; they often frequent shallow and reedy places and bask in the sun. They approach their prey slily and sideways. The prey is held in the mouth

* Genus *Lepidosteus.*

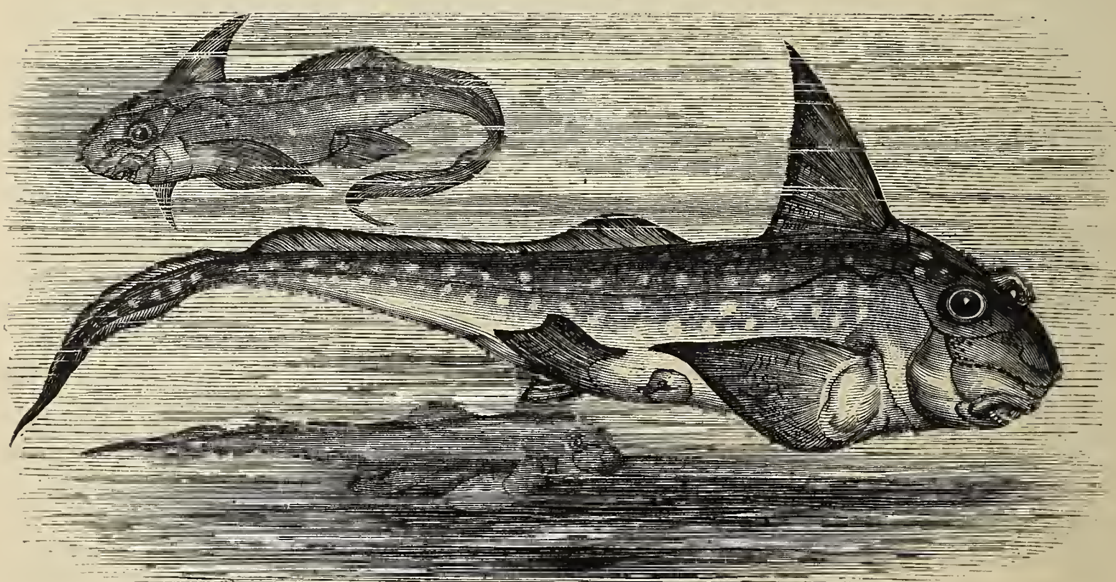
and turned until placed in a proper position for being swallowed, when it is eaten in the same manner as food is taken by Lizards. The teeth are arranged in double rows, but are of unequal size. The larger teeth are in the lower jaw. The stomach and liver are both large, and the pancreas is in the usual position. The intestine has a rudimentary spiral valve. These fishes come to the surface for air. They attain a length of upwards of five feet. In the *Lepidosteus osseus* the second row of teeth in the upper jaw is found on the palatine bones in young specimens, but in the adult only minute teeth are to be seen in this position. In the *Lepidosteus viridis* the teeth on the palatine bone are larger, and similar to the strong teeth on the maxillary. The larger teeth have their bases folded, somewhat after the pattern of the fossil Labyrinthodonts. Professor Cope includes both the genera Amia and Lepidosteus with the Teleostean fishes.

ORDER III.—HOLOCEPHALA.*

FAMILY.—CHIMÆRIDÆ.

The Chimæra, which has sometimes been called the "King of the Herrings," is like Sharks in having the nose projecting in front of the mouth, and resembles some Skates in the long tail, which tapers like a whip. But it differs in wanting the openings for the gills which are visible in both those groups; not that they are absent in the Chimæra, but are concealed by a backward fold of membrane like a rudimentary operculum, which extends in front of the pectoral fin. Under this membrane, which gives a single external opening for the gills on each side, are four clefts in the gill-cavity. There is another very important difference from the Sharks, in that the skull is blended with the jaws. The skeleton is almost entirely formed of cartilage, and almost the only bones in the body are those which form the jaws. The genus has hence been placed, together with an allied genus, as a separate division of the cartilaginous fishes (*Holocephala*). Very little is known of the habits of the Chimæra monstrosa, for it comes to the surface only in the night, and is rare in these latitudes. It is frequently met with in the Polar Seas. Its ordinary food consists of Crabs and Shell-fish, but it also travels in pursuit of Herrings and other migratory fishes. It is also said to feed on Jelly-fish. The flesh is reported to be hard and coarse-eating. Oil has sometimes been obtained in Norway from its liver, and used for disorders of the eyes. The genus is represented by three species, but the common Chimæra ranges round the shores of Europe, and is not unfrequently caught on the Mediterranean coasts of France; and it is met with at the Cape of Good Hope and in Japanese waters. This species is hardly more than three feet long; the

* ὅλος, entire, solid; κεφαλή, head.



CHIMÆRA COLLIEI.

colour is brown with marble-like markings of a lighter shade, often silvery-white. Behind the head rises the first dorsal fin, hardly separated from the second dorsal which extends all down the body. These fins have sometimes been compared in appearance to a mane. The large pectoral fins are remarkable for having their central portions fleshy, as in the Australian Ceratodus. The eggs are contained in very large leathery cases, the edges of which are like velvet. The male fish is distinguished by having jointed claspers, which are armed with small spines, and carries a very remarkable crest on the front of the head. The teeth are altogether unlike those of other fishes, since they consist of minute denticles firmly massed together into large tabular plates, which are inseparably blended with the jaws. The jaw-bones are well ossified, and have no trace of the cellular texture so characteristic of the bones of Plagiostomatous fishes about to be described.

The *Chimæra colliei* is known from the west coast of North America, and the *Chimæra affinis* from the coast of Portugal.

The second Chimæroid genus—Callorhynchus—is found only at the Cape of Good Hope and in the Southern Pacific. The only known species is named *antarcticus*. It is distinguished from Chimæra by having a remarkable cartilaginous prominence upon the snout, which terminates in a flap of skin. There is the same long and strong spine in front of the first dorsal fin. The extremity of the tail, which has an upward turn, has a fin along its lower edge, while the Chimæra has a low fin both above and below the tail. The anal fin is better developed than in the Chimæra. The pectoral fins are remarkable for their large size. The young have a double series of small dermal spines on the crown of the head and on the back of the body and tail; but as the animal grows older they become more or less hidden by the skin, or otherwise disappear. The upper part of the body in the young is always black, with more or less of white markings and spots, but in the adult there is a blackish lateral band. The claspers are almost cylindrical, and have a channel running down the interior, which opens by a lateral slit. In the true Chimæras the clasper of the male is usually divided into two branches, which differ in form in the different species, and the inner branch is again subdivided into two, so that the clasper is tripartite.

ORDER IV.—PLAGIOSTOMATA, OR FISHES WITH OBLIQUE MOUTHS.*

Sharks and Rays form one of the natural divisions or orders of fishes which is named the Plagiostomata. The skin is rarely covered by overlapping scales; if it is covered at all with defences, they usually take the form of a rounded boss, from which a little spine, resembling a tooth, rises. This covering constitutes the shagreen of Sharks, and the scales were termed by Agassiz "placoid." Besides these, the body sometimes carries bony defences, which are usually placed in front of the fin, sometimes on the back, or occasionally on the tail. The vertebræ of Sharks usually consist of two thin cones, which join each other point to point, and are connected together by bony plates, which radiate from the centre to the circumference of the inter-space between the cones, and are at right angles to their surfaces. In the Rays the vertebræ are united in the fore part of the body into a continuous bony mass, resembling the sacrum in the hinder part of the body of mammals and birds. Among some Sharks the slender arches over the bodies of the vertebræ are sometimes twice as many as the centrums. Many of these fishes have the end of the tail bent upward, and the fin is entirely below this bent portion. These fishes are termed Heterocercal, but some Sharks have the tail more nearly symmetrical, and approach the Homocercal type of bony fishes. In the Plagiostomata the brain-case is formed

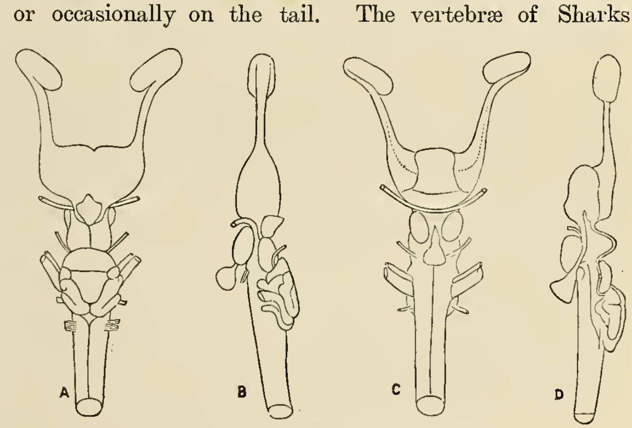


DIAGRAM OF BRAIN OF SKATE.
A, Upper View; B, Side; C, Under; D, Section.

* πλάγιος, slanting, στόμα, mouth.

entirely of cartilage, and terminates backward in two oblong processes called the occipital condyles, by which it joins on to the backbone or vertebral column. In this character there is a resemblance to the amphibia and to mammals; but the cartilaginous skull is covered with a thin layer of bone, which is deposited in cells like a minute tesselated pavement or honey-comb. There are large open spaces covered with membrane in the upper part of the skull. The upper jaw is not subdivided into separate bones any more than the skull; and the lower jaw also, unlike that of all other fishes, and like that of mammals, consists of a single piece of bone on each side. As there is never any cover to the gills, the opercular bones are also wanting. There are two pairs of lateral fins, which correspond to fore and hind limbs. The teeth vary in character. In the Sharks they are commonly sharp and pointed, and adapted for seizing and biting, but in the Rays they are more frequently blunt, and adapted for crushing. They are replaced when worn. These fishes never have an air bladder; the intestine is always short, and terminates in a spiral valve. The part of the heart termed the aortic bulb is remarkable for containing three sets of valves for controlling the circulation. A great many Sharks and Rays have a tube leading from the mouth to the upper side of the head, which is called a spiracle. In the Sharks the gills open by five or seven vertical slits on the sides of the head. In the Rays there are always five pairs of gill-openings, which are placed on the under side of the body. The Saw-fishes connect these two groups. The brain is chiefly remarkable for the large size of the cerebellum, and the great development of the olfactory lobes. Usually there are two ovaries; but in certain Sharks there is but one. The eggs are large and few, but are laid only by Dog-fishes and Rays. The great majority of Sharks bring forth their young alive, and the young are sometimes attached to the body of the parent. The claspers of the males are often large organs.

SUB-ORDER I.—SELACHOIDEI, OR SHARKS.

The Sharks all have a more or less cylindrical body, which tapers to the snout and contracts gradually into a tail. The group has been divided into nine families, though the characters by which they are distinguished depend chiefly upon external characteristics. The families are named from typical genera Carchariidæ, Lamnidæ, Rhinodontidæ, Notidanidæ, Scylliidæ, Cestraciontidæ, Spinacidæ, Rhinidæ, and Pristophoridæ.

FAMILY I.—THE CARCHARIIDÆ.

These fishes form a large family distinguished by having an anal fin and two dorsal fins and a nictitating membrane, or third eyelid, like that of birds. The family includes eleven genera. The first dorsal fin is always placed opposite the space between the pectoral and ventral fins, and never carries a spine on its anterior margin. Dr. Günther has divided the family into several sections, some of which may be regarded as themselves forming families. In the genus Carcharias, in which there is always a pit at the root of the tail, and never any spiracles, the teeth, which are more or less triangular, have a single sharp cusp; they extend round a crescent-shaped mouth. In one section of the genus the teeth are more or less denticulated, but in the other section the teeth show no trace of serrations on their cutting margins. In Carcharias, Dr. Günther recognises thirty-five species, which have been classed by the characters of their teeth into as many as five sub-genera. The majority of these fishes are known from tropical seas. Their snouts are sometimes greatly elongated, but frequently blunt. The number of teeth varies in the different species, and is not always quite the same in both jaws, but usually ranges between twenty-five and forty-nine; the difference is rarely more than two in the upper and lower jaw, and frequently there is only a difference of one. Occasionally the excess is in the upper jaw, but more frequently in the lower jaw. The Blue Shark of our own shores belongs to the section with serrated teeth.

THE BLUE SHARK.*

Towards Midsummer the fishermen on the Cornish coasts often find their nets and lines attacked by the Blue Shark. It follows the Pilchards and Herrings, and frequently bites out the part of the net in which the fish are entangled. When the bait on a line has been swallowed, and the fish has failed to bite the line through, it often rolls the rope round its body until it reaches the surface, coming up in

* *Carcharias glaucus.*

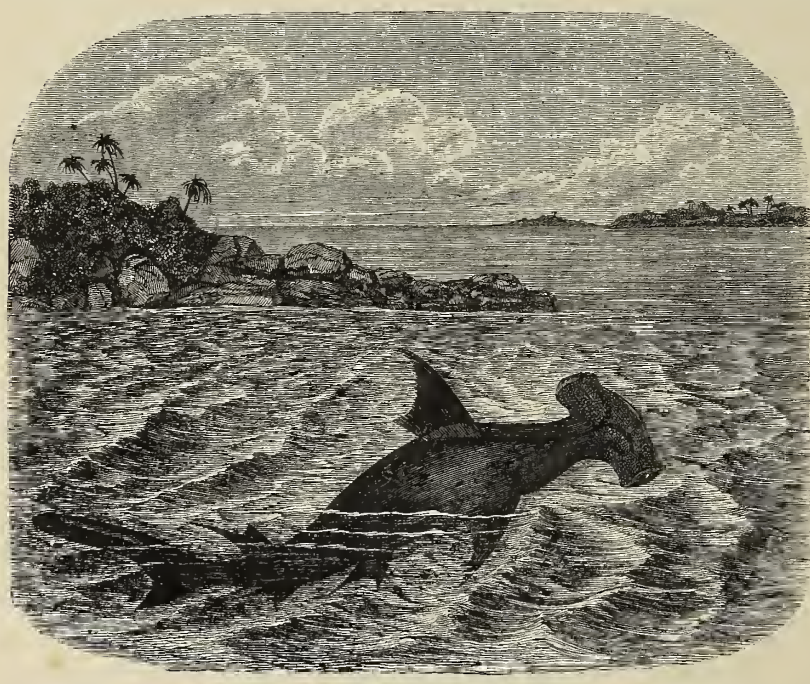
this way from a depth of thirty or forty fathoms. Its appetite shows a varied taste; the stomach of one fish six feet long was found to contain a large Piked Dog-fish, a Conger Eel, and a Grey Gurnard. Another was hungry enough to take the bait, though its stomach contained four Mackerel, half a Garfish, and a quantity of Herrings, which the fishermen, finding uninjured, afterwards sold for eighteen-pence. On one occasion a Blue Shark leaped a considerable distance out of the water to seize a piece of beef hanging on the quarter of a ship, and it is well known to attack man; but as it rarely enters harbours or approaches close to the land, its human victims are few. Fishermen assert that its sense of smell is offended by nauseous odours, so that it may be driven away by pouring bilge-water into the sea where it shows itself. The muscular vitality of these fishes is as remarkable as that of Reptiles and Amphibians, for in one recorded instance, after a Shark had been caught, and the body severed from the head and thrown overboard, it continued swimming about for hours. The power of the Shark's tail often makes the fish an inconvenient neighbour when drawn on deck, but when the tail is chopped off this danger is removed. It is, however, usual to disable the animal by a blow on the snout. It is occasionally accompanied by its young, which in June are about eighteen inches or two feet long. It remains in these seas, sometimes straying as far north as the Orkneys, throughout the summer, and disappears in the autumn. Many hundreds are captured in a season by British fishermen; but the body is used only for manure, and oil is made from the liver. The largest examples are said to reach a length of fourteen feet, but the usual size is six or eight feet. It is distributed throughout temperate and tropical seas, and has been recorded from Pondicherry, St. Helena, and the Mediterranean, but neither the limit nor direction of its migrations is at present known. The animal derives its name from the colour of the fins and the upper parts of the body, though the belly remains white. The mouth is placed far behind the projecting nose, and armed with triangular teeth which have their margins serrated like saws. The skin is rather rough, and the pectoral fins are large. The other fins are all small. All the fishes of this genus have the first dorsal fin placed over the space between the pectoral and ventral fins, and there never is a spine in front of this fin. The gill-openings are small, five in number, and are placed just in front of and above the pectoral fin. The majority of fishes allied to the Blue Shark are from the neighbourhood of the Malay Archipelago and Indian seas, but two or three species out of the thirty-five which are known frequent the West Indies and Tropical America.

There are many genera allied to Carcharias which have no representatives in the British seas. Among these are the Hemigaleus, from Java and Amboyna; Loxodon, from the Indian Ocean; Galeocerdo, which is represented in the Arctic seas by a species ten feet and a half long, while smaller species are found in the Atlantic and Indian Oceans and Australian seas. Thalassorhinus is found in the Mediterranean and the Atlantic. These four genera are all characterised by having spiracles, which distinguish them from Carcharias. They differ from each other in the characters of the teeth, lips, and tail.

The next genus, Galeus, differs from all the foregoing in wanting the pit at the root of the tail. Only two species are known, one from Japan, and the other (*Galeus canis*) is the common British Tope, widely distributed throughout all temperate and tropical seas, and ranging to the Pacific and Antarctic Oceans. It is common on our southern coasts in summer, and reaches a length of about six feet, but is usually smaller. It is in summer that the young are brought forth. The number produced at a time varies. Couch records twenty-one at a birth, and sometimes thirty-two, but says that fifty-two have been known. The young when born are about a foot in length; they do not attain their full size until the second year, and remain near our coasts through the first winter, though, as their size increases, they retire into deep water and swim low. When hooked, this species often, like the Blue Shark, twists the whole length of the line round its body. In France and Italy the Tope is used for food, being eaten fresh; but more frequently the flesh is dried, and afterwards soaked and grilled or stewed, but the only use made of it in this country is melting the liver for oil. The young are commonly known to fishermen as the Miller's Dog, and the larger specimens as the Penny Dog. The young have the snout much shorter than that of the adult. The colour is a dark ash-grey above and white below. The teeth are serrated on the outer border, from which the smooth cusp projects outwards, but the broad front teeth are serrated on both sides. The gill-openings are five, placed in front of the pectoral fin, and are very short. There are one hundred and forty vertebræ.

THE HAMMER-HEADED SHARK.*

The Hammer-headed Shark differs from all others in having the sides of the head prolonged outward in the form of a capital T. The eyes are placed at the extremities of these remarkable transverse processes, and furnished with eyelids. The iris is of a bright golden yellow, with a black pupil. The mouth is relatively small, has the semicircular form usual among Sharks, is placed on the under side of the transverse expansion, and carries three, four, or five rows of triangular teeth, the rows becoming more numerous with age. The cutting-edges of the teeth in this Shark are smooth in the young, but become serrated later in life. The teeth have no barbs at the sides. The nostrils open in front of the head, and are elongated. There are five clefts for the gills, which are at the side of the body, and placed between the pectoral fins and the hammer-like expansion which carries the eyes. This fish has two dorsal fins; the anterior one is placed over the space between the pectoral and ventral fins, and the hinder one is over the anal fin. The upper lobe of the caudal fin is long. The specimens captured in British seas are brown on the back and paler on the under side, ten feet long, and measuring six feet in circumference. They are said to weigh between six and seven hundred pounds. The body of a female contained thirty-nine young ones, perfectly formed, each about nineteen inches long. The species frequents deep water, and is said to be ferocious. It has been taken on the Cornish coast, at Tenby, and on the coast of Norfolk. But its home appears to be in tropical and sub-tropical waters, since it is often met with in the Mediterranean, round the shores of the Indian Ocean, in the seas between China and Japan, and ranging southward through the Malay Archipelago as far as South Australia. There are in all five species known of this remarkable genus; and the other species occur in the Red Sea, on the coasts of India, in the Gulf of Mexico, and tropical parts of the Atlantic, but they all appear to have a wide range, and the Atlantic species has been met with in the Indian and Chinese Seas. Dr. Günther regards this genus as forming a second group of the Carchariidæ, which he names Zygænina.



THE HAMMER-HEADED SHARK.

The third group in the family is Mustelina, from its type Mustelus. It comprises the genera Triænodon, from the Indian Ocean; Leptocarcharias, from South Africa; Triacis, from the Pacific and Indian Oceans; and Mustelus, which is represented by five species widely distributed in temperate and tropical seas.

THE SMOOTH HOUND.†

The only British species of Mustelus ranges round the European coasts, and probably extends as far as the United States. The name Smooth Hound refers to the circumstance that the skin is softer than the skins of other British Sharks. It grows to a length of about three feet, but is

* *Zygæna malleus.*

† *Mustelus vulgaris.*

usually taken smaller. It is said to be sometimes used for food in the Hebrides. The mouth is below the eyes, and the teeth are flat like a pavement, and form crushing surfaces adapted to masticate the crustacea upon which these fishes usually feed. It is not very prolific, producing about a dozen young simultaneously in the month of November. The embryo is not attached in this species to the body of the parent. The caudal fin is short, and its hinder margin is usually whitish; the colour of the body is a uniform grey, with small whitish spots above the lateral line. These spots

THE SMOOTH HOUND.

are most marked in young specimens. In this genus the second dorsal fin is not much smaller than the first. There is always a nictitating membrane; there are small spiracles behind the eyes; and there is no pit at the root of the tail.

FAMILY II.—THE LAMNIDÆ.

The second family of Sharks (*Lamnidæ*) has no nictitating membrane, and no spiracles, or only minute foramina to represent them. The gill openings are usually wide. Dr. Günther divides the family into two sections: first, the Lamnina, which includes Lamna, Carcharodon, Odontaspis, and Alopecias; and secondly Selachina, which includes the genus Selache, and possibly the Portuguese genus Pseudotriascis.

The best known of the three species of Lamna is the Porbeagle Shark, sometimes called the Beaumaris Shark (*Lamna cornubica*), which occurs on our own coasts and in the Mediterranean and

Atlantic, and has been taken in the Japanese seas. It is sometimes captured in mackerel nets and salmon nets, and has been taken on lines set for haddock. Cuttle-fish, cartilaginous fishes, hake, pilchards, and herrings, form its usual food. It appears to grow rapidly in early life, since it is nearly full grown before the second row of teeth is cut. Large specimens weigh fully eight hundred pounds, but the usual size is a length of four feet, with a body measuring two feet round in front of the pectoral fins. It is eaten in the Mediterranean, and used as manure in this country. In the back-bone there are 155 vertebræ.

In the genus Lamna the teeth are lanceolate, but there are not always little cusps at the base, though they are characteristic of the Porbeagle Shark. In that species the third tooth of the upper jaw on each side is remarkably small, and the width of the first gill-opening is equal from its distance to the last. There are specimens in the British Museum eight feet long.

The genus Carcharodon is known only from a single species which ranges from the Mediterranean to Australia. It has large, flat, regularly triangular teeth, with serrated margins, twelve on each side in the upper jaw and eleven on each side in the lower jaw. Fossil species have teeth which are sometimes nearly eight inches long. The second dorsal fin is placed in front of the anal fin. There are jaws in the British Museum obtained from Australian specimens which Dr. Günther states to have been thirty-six feet and a half long, and he appropriately quotes this species as the Great Blue Shark.

THE THRESHER, OR FOX SHARK.*

This species has acquired the name of Fox Shark from the enormous length of the upper lobe of its tail. The pectoral fins are very large, and the first dorsal fin is large. The teeth are triangular, and are not serrated. It is the only species of its genus, and is chiefly found in the Mediterranean and Atlantic. Specimens caught on the British coast have measured about eleven or twelve feet in length, one-half of which is formed by the tail. The snout is conical. Couch records that a splash of the tail of the Thresher puts a herd of Dolphins to instant flight; and instances are recorded of the Sword-fish and Thresher combining to attack large Whales. The stomachs of Threshers have generally been found filled with Herrings. It is rarely taken with the line, but is sometimes caught on the west and southern coasts in drift nets. The flavour of its flesh has been compared to that of the Salmon.

THE BASKING SHARK.†

The Basking Shark is one of the largest fishes of the group to which it belongs. It is sometimes as much as thirty-six feet in length. The circumference is enormous in proportion to the length. One which had a length of thirty-three feet measured twenty-four feet round. Its weight may be as much as eight or ten tons, and the height of its body above the ground may be eight or nine feet. This fish has the remarkable habit of floating on the surface of the sea and basking in the sun. It is generally seen between June and the beginning of winter; it abounds on the coast of Donegal, and frequents the west coast of Scotland when the wind is northerly. Westerly winds appear to bring it up the English Channel, and during their prevalence it has been seen, or cast ashore along the southern coast of England. These Sharks frequently swim in pairs, following each other, and the long moving mass has more than once been described as a Sea-serpent. On one occasion the Sea-serpent was supposed to have been cast ashore on the Sussex coast; when examined it was already in an advanced state of decomposition, but was measured by the village schoolmaster, and sketched, and considered to have a length of about seventy feet. Fortunately a few joints of its back-bone were collected, and afterwards examined. They presented all the characters of the vertebræ of the Basking Shark; and two large individuals lying end to end satisfactorily accounted for the supposed length of *that* Sea-serpent. The teeth of this Shark, in proportion to its size, are smaller than in any other member of the group, rarely attaining the length of an inch. The gape of the mouth may amount to as much as three feet. These Sharks are remarkable for the large size of the liver, which yields an immense quantity of oil. Couch, quoting from Brabazon's account of the fisheries of Ireland, says that large shoals of these Sharks pass annually in April and May to the north along the west coast of Ireland, where they are known as the Sun-fish, and are seen from a distance, about a hundred miles west of Clew Bay, lying motionless on the surface of the water, out of which the large dorsal fin rises like a

* *Alopecias vulpes.*

† *Selache maxima.*

sail three or four feet high. They are easily approached and struck with a harpoon, when the fish at once darts away, and carries out from seventy to two hundred fathoms of line. Reaching the bottom he rolls himself, and rubs his wound against the ground to get free from the harpoon. After about an hour the fishermen begin to haul upon the harpoon line, which is coiled up in preparation for the fish making another rush. In this way he is often played with for eight or nine hours before he can be got to the surface. When this happens two or three more harpoons are fixed in him, and he is drawn alongside the vessel, stretched fore and aft. A jowl rope is got round his head, and a hawser round his tail. The tail is then cut deep on each side with a hatchet, and the fish in its agony lashes so furiously that the tail becomes broken. Large flesh holes are then cut in the body on both sides, and through these ropes are passed; then by hauling on one side and slacking the rope on the other the fish is canted over on his back. The fishermen then split down the stomach and take out the liver, which is said to weigh about two tons, and to make from six to eight barrels of oil. The rest of the fish is cut adrift, for the fishermen have a superstition that if the bodies were brought on shore the Sharks would abandon the coast. They require to be harpooned with great caution, low down on the side of the dorsal fin, so that the weapon may go through the intestines; or they are sometimes struck near the tail vertebræ; but this operation requires care, as a blow from the tail would stave in the boat. As many as five hundred of these Sharks have been killed in a single season. Their value ranges from £35 to £50 each. Oftentimes a hundred of them together may be seen towards the end of June basking in the sun on the north-west coast of Donegal. In the Orkneys they appear to be rarer. The liver of one twenty-seven feet and a half long captured near Whalsey in November yielded 165 gallons of oil, and was sold for £16 10s. That shark was caught by the herring-fishermen with a six-oared boat. It appears to have taken a mouthful of herrings, and then to have rolled the net with the ropes five times round its body. Two Scottish specimens thirty feet long, caught at Broadhaven, yielded nineteen barrels of oil, eight of which go to the ton.

The body is thickest in the middle, is nearly cylindrical, and tapers to the two ends. The skin is rough with the shagreen covering, and dark-brown in colour. The head has a conical form, with a short muzzle, covered with a number of circular pores. The eyes are small and near the snout. The iris is brown. There are five branchial clefts in front of the pectoral fins which are remarkable for their enormous depth, so that they go far to encircle the anterior part of the body. The nostrils are small, and placed laterally on the edges of the upper lip. The second dorsal fin is much smaller than the first. From the anal fin to the base of the tail the body has a prominent keel on each side. The caudal fin has a large upper lobe and a small lower lobe, but its form varies with age and the rough usage to which it is subjected. Its food is said by Linnæus to consist of Medusæ, but there are no satisfactory records of animals found in its stomach. A fine specimen cast ashore at Shanklin is preserved in the British Museum. It is a species which especially frequents high northern latitudes.

FAMILY III.—RHINODONTIDÆ.

This family is known only from the *Rhinodon typicus*, caught between the Cape of Good Hope and the Seychelles. Like the Basking Shark, it has a keel on the tail, and the teeth are extremely small, numerous, and conical, and the mouth is placed near to the extremity of the snout.

FAMILY IV.—NOTIDANIDÆ.

This family is also known only from a single genus, Notidanus, in one species of which there are six gill-openings, forming the section Hexanchus, while in the other three species the gill-openings are seven, forming the section of the genus named Heptanchus.

THE SIX-GILLED SHARK.*

The Grey Shark is sometimes eleven or twelve feet long. It possesses but one dorsal fin, which is placed just over the anal fin, and is not supported by a bony spine. The snout is rounded, thick, and blunt. The eyes are large, slightly oval, and placed just above the corners of the gape of the jaw. There is no eyelid to defend the eye. The teeth form a single row in each jaw. In the lower jaw the crowns are oblique and serrated. They are six in number on each side. In the upper jaw there are six teeth on each side; their points are slender and sharp, without serrations,

* *Notidanus griseus.*

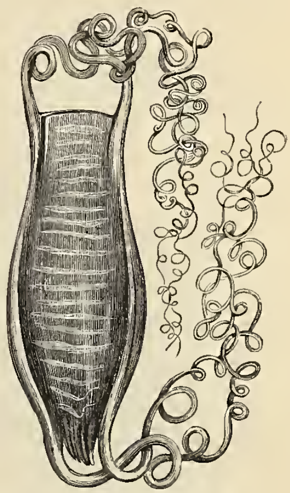
and are directed towards the angles of the mouth. In front, in the middle line, are four more awl-shaped teeth. The six openings for the gills are placed very close together, and extend under the throat so as almost to encircle its lower part. The scales are very short and leaf-shaped, with a median keel which runs to the sharp point. Specimens taken off Ventnor have measured eleven or twelve feet in length. The pectoral fins are unusually wide and triangular. The caudal fin is about a quarter of the length of the fish, and more slender than in any other British Shark except the Thresher. The hinder two-thirds of the upper margin of the tail are armed with three parallel rows of spines, the lateral rows diverging outward. Though known as the Grey Shark, the back and fins have a blackish-brown colour, but it is white underneath, and of a warm grey tint at the sides. It has several times been taken with a line on the South coast of Britain. Large specimens are said to have many rows of teeth in the lower jaw. It is often met with in the Mediterranean, and frequents the Atlantic. The three other Sharks closely allied to this, which have been placed in the section Heptanchus, are *Notidanus platycephalus*, distinguished by its short blunt snout, which is found only in the Mediterranean; and the *Notidanus cinereus*, found in the Mediterranean and adjacent coasts of the Atlantic, which has the snout prolonged and pointed. The third seven-gilled Shark, called *Notidanus indicus*, ranges from the Cape of Good Hope to California.

FAMILY V.—THE SCYLLIIDÆ, OR DOG-FISHES.

The term "Dog-fish," as might be expected, is used vaguely by fishermen for a number of distinct Sharks. Along the English coasts there are several nearly-allied forms known as the Spotted Dog-fish, or Nurse Hound, and the Black-mouthed Dog. The Nurse Hound, or larger Spotted Dog (*Scyllium stellare*), and the smaller species known as the Rough Hound, or lesser Spotted Dog (*Scyllium canicula*), usually live at the bottom of the sea, and in rough and rocky places. They feed for

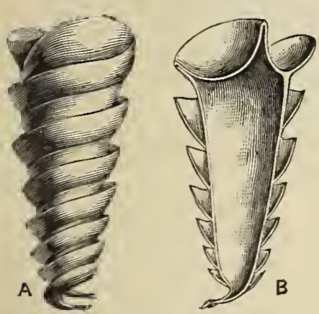
THE NURSE HOUND.

the most part on Crabs and Lobsters, though they readily take any tempting food that comes in their way. They rarely come near into shore, and are caught in summer and autumn. The eggs of these fishes are contained in oblong purse-like cases, as tough as leather, with long tendrils at the four corners, which coil up and hold the egg to some coralline, or gorgonia, or sea-weed. The eggs are deposited one or two at a time. The Nurse Hound deposits them late in the year, but the Rough Hound lays its eggs throughout summer and autumn. Its purses are of a pale yellow colour, with tendrils which may be stretched out to a length of two feet. The eggs have been found unhatched as late as the middle of December. There are four slits at the corners of the egg-case, but their function has not been discovered. The flesh of the Nurse Hound is too rank to be eaten, but in the west of Cornwall the Rough Hound is made into Sea-dog soup, called from its ancient British name "Morghi," but in the Mediterranean the Rough Hound appears to be an ordinary item of food. Sharks are of rapid growth, and reach their full size in a few years, but there are no means of judging what age they attain. The Nurse Hound grows to a length of four or five feet. Its colour is dusky-red, with many large dark spots on the body and fins. The skin is rough with minute spines, which are directed backwards. The body is elongated posteriorly; the pectoral fins are placed low down at the sides of the head, and are wide. There are five small branchial clefts placed close together in front of the pectoral fin. The mouth is very close to the end of the snout, and when opened is circular. The Black-mouthed Dog-fish, which forms the genus Pristiurus, differs in having a long snout with the mouth placed below the large eye. It is well known in Italy, where it has received from the Italian fishermen the name "Bocca d'Inferno," or "Mouth of Hell." The eggs are deposited in cases which have, according to Yarrell, the tendrils at one end only, and too short to be capable of twining round any fixed substance. The purses are about an inch and a half long, of a tawny yellow-brown colour, with a smooth shining surface. The body is spotted, but the spots are oblong and arranged in two rows. The colour of the upper part is made up of many tints of brown and yellow, while the belly is pale. The dorsal fins are placed far back, the first dorsal beginning behind the ventral fins. These fishes are a little over two feet long.



EGG PURSE OF NURSE HOUND.

The Dog-fishes are widely distributed, some of the species ranging over the Indian Ocean, others from Japan to Amboyna; one is recorded from Tasmania, another from Chili, and one or two from the Cape. There are in this family five other genera, which have much the same distribution as the genus Scyllium.



EGG OF CESTRACION (A); SECTION OF THE SAME (B).

FAMILY VI.—CESTRACIONTIDÆ.

This family is known only from the genus Cestracion, of which there are four species. Here, for the first time, spines are met with in front of both the dorsal fins; the nostrils unite with the cavity of the mouth, which is narrow, and has the upper lip divided into seven lobes. The teeth in both jaws are similar; they change their character as the animal grows older. In the middle there are small teeth, which at first have from three to five cusps, but afterwards become small and blunt. External to these are large lateral teeth, twice as broad as long, which are arranged in oblique series so as to form a sort of tesselated crushing surface. The best known species is the Port Jackson Shark (*Cestracion philippi*), which ranges from Japan to New Zealand. The backbone contains a hundred and ten vertebræ, only fourteen of which intervene between the skull and the first dorsal spine. The body is marked with more or less distinct dark bands, which give the fish a Zebra-like appearance. There is a second Australian species, one from the Galapagos Islands, and another

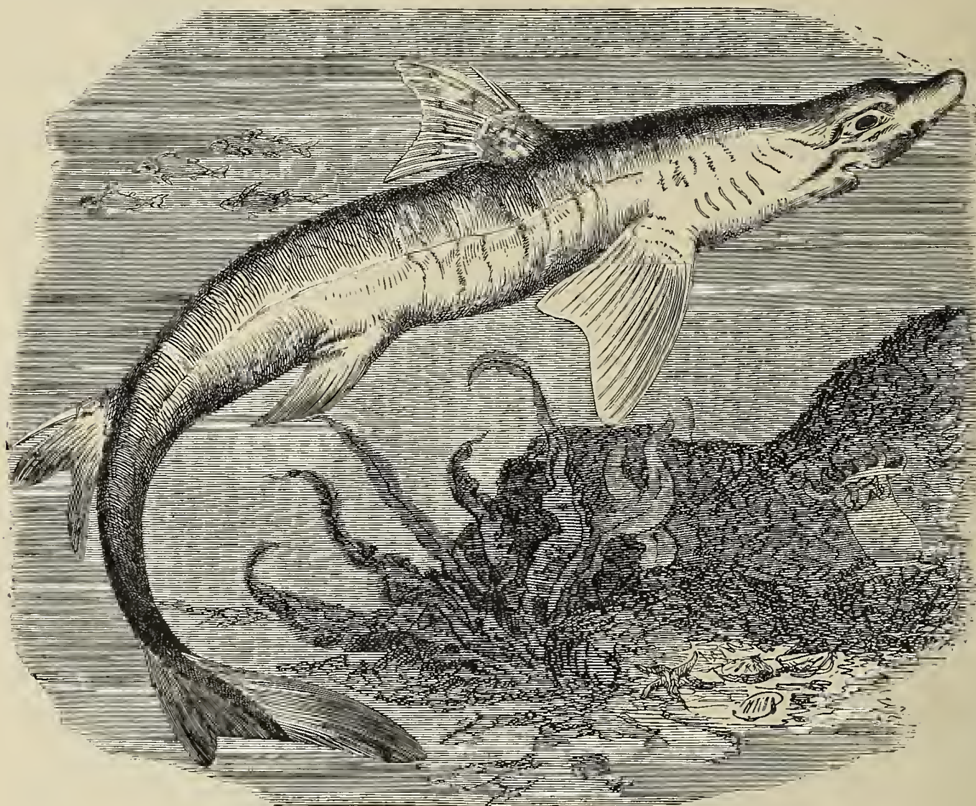
from California. Both the latter are distinguished by having round black spots over the body and fins. All the species are small.

FAMILY VII.—SPINACIDÆ.

This family includes ten genera. The genus Centrina is found in the Mediterranean, on the coasts of Portugal. Acanthias, known from three species, like all the other members of the family, wants the anal fin. The British representative is called

THE PICKED DOG-FISH.*

The Picked Dog-fish is the smallest and most abundant of British Sharks. It is most plentiful on our west and south coasts, and Couch records that the sea is often covered with it for scores of miles, and



THE PICKED DOG-FISH.

that twenty thousand have been taken in a seine net at one time without visibly lessening their numbers. It is a remarkably hardy fish, and never seems to suffer either from the severity of winter cold or summer heat. The name is derived from the spines placed in front of each of its two dorsal fins. On the coast of Kent and Sussex it is usually known as the Bone-dog; in Orkney it is the Hoe; in Cornwall the male is known as the Skittle-dog. The spines are used as offensive weapons, and are directed with marvellous accuracy against the object to be pierced. For nine or ten months in the year the female produces young almost every day. The young are extruded in pairs, and develop rapidly. Yarrell records that these Sharks have occasionally been found in a monstrous form, there being two heads, with the separation continuing backward to behind the pectoral fins; but there is no evidence that such monsters attain to maturity. The young ones accompany their parents in pursuit of prey, though their jaws are too feeble to capture or even attack the fishes on which their parents feed. Frequently this fish bites jagged holes in the net, and cuts the hooks from the fishermen's lines. It has

* *Acanthias vulgaris.*

been found in the stomach of the Blue Shark, the Ling, and other fishes. It is eaten, both fresh and salted, by the fishermen of the West of England, and Lacépède records that in the North of Europe the eggs, which consist of pale-coloured yolk, and have the size of a small orange, are highly valued as an article of food. The usual length of the fish is between eighteen inches and two feet. The female is larger than the male, and old specimens have been found which weighed twelve pounds. The top of the head is flat. The first dorsal fin, which is rather small, is placed a third of the length of the animal from the snout; the second dorsal fin is midway between the first and the end of the tail. The upper part of the body is of a slaty-grey, and the under parts are yellowish-white. From head to tail the skin is smooth, but in the opposite direction rather rough. The species ranges throughout the European seas, and is taken in the western part of the Mediterranean, at the Cape of Good Hope, and on the coasts of Australia. The dorsal spines are distinguished by having no longitudinal groove on the sides, a feature which is also characteristic of the Mediterranean species *Acanthias uyatus*.

The genus Centrophorus is represented by eight species. In one of these (*Centrophorus cœlolepis*), from the coasts of Portugal and Madeira, the dorsal spines are hidden beneath the skin. All the species are covered with scales, and in three there are from four to six keels on each scale; in two there is only a single median keel. Another species has three strong ribs on each scale, each rib terminating in a point, and in all these species the spines of the dorsal fins project beyond the skin. The species are all small, rarely exceeding a length of three feet, and the colour is generally brownish-black.

The genus Spinax occurs in the European seas, and one species (*Spinax pusillus*) ranges across the Atlantic from Cuba to Madeira. Both species are of brown or black colour, and reach a length of twelve or fourteen inches.

The genus Centroscyllium is known only from a single species from Greenland, about two feet six inches in length.

Scymnus lichia is from the Mediterranean and Atlantic.

Læmargus has one representative in the Mediterranean and another (*Læmargus borealis*) in the Arctic seas, where it attains a length of twenty-five feet. Smaller specimens of this species from time to time visit our own shores. According to Scoresby, it is an enemy of the Great Greenland Whale. It often bites pieces out of the flesh of the living animal, but when the Whale is dead it gorges itself upon the blubber, and refuses to be driven away, even though pierced through with a spear. It will also feed on small fishes and crabs. When fresh it is brown, deeply shaded with blue. The rows of teeth vary with age, from two to six. The simple cusps in all the rows diverge laterally from the centre.

The genus Euprotomicrus is known from a small species found in the Indian Ocean.

Echinorhinus also has but one species, which is known as

THE SPINOUS SHARK.*

The Spinous Shark ranges in the Atlantic from the shores of Britain to the Cape of Good Hope, and sometimes enters the Mediterranean. It is of an awkward shape, and is remarkable for small fins and small tail. It would appear to feed chiefly upon crustacea. The liver of a specimen five feet and a half long yielded a gallon of oil, but specimens have been taken between eight and nine feet long. The body is covered with sharp spines, which are absent from the snout and fins and from the belly. The dorsal fins are close together, and both near the tail. It has been taken in the trawl-net, and on lines baited with cuttle-fish. The fins have a reddish-brown colour; the eyes are green; the sides and belly are reddish-yellow, with vermilion blotches. The gape of the jaw is wide, and the teeth are large, compressed, and have the cutting surface horizontal, usually with two cusps on each side. The bases of the spines on the body are circular, and the spines are slightly recurved. The lateral line is well marked; it originates above the five openings for the gills, and extends backwards to the commencement of the caudal fin, which it then ascends to its upper extremity.

FAMILY VIII.—RHINIDÆ.

This family contains only the Monk-fish, or Angel Shark.

* *Echinorhinus spinosus.*

THE MONK-FISH.*

The Monk-fish, or Angel Shark, has a form and appearance intermediate between the Sharks and Rays. This is owing to its greatly-expanded pectoral and ventral fins, which more closely approach in plan to those of the Sharks, since the bones which form them consist of an expanded piece which has a narrow surface approximating towards the vertebræ, and gives off from its outer margin a number of rays, so as to present some resemblance to a palm-leaf. The body is

THE MONK FISH.

depressed, and tapers to the tail. The head, which is rounded, is separated from the pectoral fins by a short neck, and the nose is not at all developed in front of the mouth. The ventral fins are placed at the sides of the body just behind the pectoral fins, and the two small dorsal fins are between the ventral fins and the tail-fin. It generally remains near the bottom, and only rises in the water in pursuit of other fishes. It feeds chiefly on Flat-fish, and like them sometimes hides itself in the loose sand. The young are produced alive about July, when they are about a foot long. Its length appears usually to be from four to five feet, but occasionally reaches as much as seven or eight feet. The breadth of the pectoral fin is always more than half its length. The gill-openings, five in number, are rather wide, placed at the sides of the body towards the under surface, and partly covered by the pectoral fins. The skin is rough all over; a row of spines runs down

* *Rhina squatina.*

the middle of the back; there are half-circles of spines like eyebrows behind the eyes, which are placed on the top of the head, and are covered with skin, except round the pupils. Their colour is sandy-grey. There are about a hundred and twenty joints in the vertebral column; none of the vertebræ are united together, as among Rays. The arches over the spinal cord are broad plates, which cover the bodies of two vertebræ. The teeth are arranged at intervals, with four or five successional teeth behind the outermost one. This Shark was well known to the Greeks, who used its skin in polishing wood and ivory. Its flesh was also valued for food, and is described as firm and nourishing. It is still eaten in the north of France.

The males of this species, like most other Sharks, are furnished with prehensile appendages termed "claspers," but they do not here attain a large size. The species is widely distributed in temperate and tropical seas, being found in the Atlantic and on both sides of the Pacific.

FAMILY IX.—PRISTIOPHORIDÆ.

This, the ninth and last of Dr. Günther's families of Sharks, also only includes one genus —Pristiophorus—characterised by having the cartilage of the fore-part of the head prolonged into a long flat plate, which is armed on each edge with a series of teeth, so as to resemble a saw. There are also numerous rows of teeth in the upper jaw, sometimes as many as fifty-eight. The nostrils are on the under side of the head. The scales are minute and keeled, and scales more or less completely cover the dorsal and pectoral fins. The body is somewhat depressed; but the gill-openings are lateral, while in the other saw-fishes of the next family they are on the under side of the body. The species range from Japan to Tasmania, and sometimes reach a length of five feet.

The abundance of Sharks on the coasts of India appears to depend upon the presence of the Oil Sardine (*Clupea scombrina*), so that in some years, when these fishes are rare, or scarcely visit the coasts, Sharks are also comparatively scarce. They have for many years been sought for for the sake of their livers, which are used for the manufacture of medicinal oil. The livers are equally good at any season of the year, but while small livers yield one-third of their weight of oil, the large ones yield one-half their weight of oil. The best have a pinkish colour, and are firm. Those used in the manufacture vary in weight from 40 lbs. to 290 lbs. The Sharks are captured with baits of putrid beef or porpoise flesh, which are put on the hook and attached to a chain. The fishing is carried on in deep water, between four o'clock in the morning and sunset. The process of manufacture of the oil is comparatively simple; the livers have to be received at the factory within six hours of the death of the fish; the veins are slit up and the gall-bladder removed, and the gland is washed until it no longer discolours the water. It is then cut up into pieces which weigh about 4 lbs. each, placed in an earthen vessel and covered with about an inch and a-half of water. The vessel is then heated over a slow fire for about a quarter of an hour, till it reaches a temperature of 130° Fahr. It is then stirred up, and as froth begins to rise the vessel is cooled on sand. The oil floats, and is skimmed off with a ladle formed from half a cocoa-nut shell attached to a bamboo handle. This rough oil is strained through flannel, and then allowed to stand for three or four days, when it is again strained through layers of long-cloth, satin-cloth, and flannel, and again stands for a fortnight or three weeks. The straining is then repeated. In all there are six strainings, the last being through cloth and filtering-paper direct into the bottles in which it is stored. This oil has a light straw colour, and closely resembles cod-liver oil. The cost of its manufacture, however, has of late increased so much that the Indian Government, which formerly carried on the industry at Calicut, has found it less expensive to import cod-liver oil from Europe.

SUB-ORDER II.—BATOIDEI (RAYS).

All the Rays have a depressed flattened body, which is expanded by the pectoral fins into a more or less rhomboid or ovate form, usually terminated by a slender tail. Many species have the snout pointed, though this character is by no means universal. The gills always open on the under side of the body, and are always five in number. They communicate with spiracles, which open on the head behind the eyes, and supply the gills with water while the animal lies on the ground. These spiracles can be closed voluntarily. It has been estimated by Monro that, owing to the numerous foldings of the gill-surface, the entire area of respiratory tissue is equal to the whole external surface

of the human body. The auditory apparatus is well developed in all the Rays, and the eyes are more complex than those of Sharks. They are always placed on the top of the head, are directed sideways, are placed at some distance from each other, and are defended by a cartilage above, behind which there is usually a row of spines. Below the cartilage is an eyelid, which is capable of covering the pupil. The pectoral fins have a general resemblance to those of the Monk-fish, or Angel Shark. As the rays which compose the fin extend outward, they subdivide and become jointed, and in the common Thornback number eighty-two, and have twenty joints between their origin and outward termination. The ventral fins almost form a continuation of the pectoral fins. The claspers of the male are long and strong, and have joints which allow them to be moved in almost any direction. They are placed just in front of the inner side of the ventral fins. Rays have no anal fin. There are usually two small dorsal fins. All the Skates lay eggs, which are contained in a case or purse, which closely resembles that of oviparous Sharks. In the embryo the tail is relatively longer than in the adult, but Couch remarks that by a process not unlike that which deprives the tadpole of its tail, the part of the body which lies behind the dorsal fins gradually ceases to be nourished, and diminishes in size.

The Rays form the second subdivision of the Plagiostomous fishes, and compose the section Batoidei. They have been subdivided into six families by Dr. Günther. Most of these fishes feed on small crabs and shell-fish, for the mastication of which their flat teeth are well suited.

FAMILY I.—THE PRISTIDÆ.

This family, like the Pristiophoridæ, is distinguished by the same characteristic of an exceedingly long flattened snout, armed along each edge with a series of strong teeth, much like a rough saw, so that it closely resembles the last group of Sharks. The skeleton of the saw consists of three, four, or five hollow and somewhat cylindrical tubes, which taper towards the end, and are encrusted with a granular osseous layer, such as is usual in the bones of this group of animals. These tubes are the greatly elongated and enlarged cranial cartilages, which are prolonged forward in Sharks and Rays to form the ordinary rostrum or snout, though, as a rule, those cartilages vary in number from one to three. The teeth are implanted in sockets, and have square bases. It is needless to remark that these teeth of the Saw-fish have no relation to the ordinary dentary armature of the jaws, but rather correspond to the scales or tubercles of the skin, which are here implanted and developed so as to closely simulate teeth. There are five species of the genus Pristis. They agree in having the body depressed and elongated. The gill openings are on the under side of the head, are moderately wide, and placed between the pectoral fins. The nostrils are also on the under side of the head; the teeth are minute and blunt. There are wide spiracles or blow-holes behind the eye, and the eye has no nictitating membrane. The pectoral fins have the front margin free, and are placed behind the head. The species are widely distributed in tropical seas. The dorsal fin is sometimes in advance of the ventral, as in *Pristis perrotteti,* sometimes opposite the ventral, as in *Pristis pectinatus* and *Pristis antiquorum,* in both of which species the caudal fin has no lower lobe. *Pristis cuspidatus* has the dorsal fin entirely behind the ventral, and in this East Indian species the rostrum is toothless towards its base. The number of pairs of teeth in the saw varies in this species from twenty-five to thirty-four, the number apparently altering with age. In *Pristis antiquorum* the number of pairs of teeth varies from sixteen to twenty, and the teeth have the cutting edge in front only. The longest saws in the British Museum have a length of five feet, and belong to this species, which is common in the Atlantic and Mediterranean; those of *Pristis zysron,* from Amboyna and Ceylon, are equally long.

FAMILY II.—RHINOBATIDÆ.

This family includes three genera, which have the body moderately expanded, with the rayed portion of the pectoral fin stopping short of the snout. The tail is strong and elongated, and carries two well-developed dorsal fins; but the caudal fin sometimes wants the lower lobe. The family includes three genera. Rhynchobatus has the nostrils forming oblique wide slits on the under side of the head. The two species range from the Indian Ocean to the China Seas. In Rhinobatus the cranial cartilage is prolonged into a long rostrum; the space between the rostrum and the pectoral fin is occupied by membrane. The depressed body tapers

gradually to the tail. The teeth are small and obtuse, but each has a slight transverse ridge which is not seen in the previous genus. There are twelve species found in the warmer seas. The skin is usually coarsely granular, and covered with a series of tubercles, which often have large compressed spines in the median line. The mouth is commonly straight, but is occasionally arched, and is frequently longer than the nostril. Specimens of *Rhinobatus granulatus* from India, in the British Museum, have a length of seven feet, but jaws of a large example are fifteen inches wide. Most of the species appear to be smaller than this. Trygonorhina is an Australian genus, distinguished by the great width of the nasal valves.

FAMILY III.—TORPEDINIDÆ.

The Torpedo family includes six genera, which are all distinguished by possessing electric organs formed of hexagonal columns, which extend vertically, and are spread between the pectoral fins and the head. They all have the nasal valves confluent, with a quadrangular flap or lobe, as in Trygonorhina. The trunk is always a broad smooth disc.

THE GENUS TORPEDO.

The Torpedo has the body in front of the ventral fins more or less transversely ovate. The surface of the body is smooth, soft, and somewhat rounded. There are two small dorsal fins placed on the tail, which ends in a caudal fin having the lobes above and below nearly equal. Where the Torpedo marmorata occurs on the British coast it is familiarly known as the Cramp-fish, Numb-fish, and Electric Ray. When it is grasped by the hand a creeping sensation is felt in the whole limb up to the shoulder, accompanied by violent trembling and sharp pain in the elbow. As its vitality declines, the electric properties are lost, and are entirely wanting in the dead fish. The shock is sufficient to kill a duck, and in one of the early experiments made by Mr. Walsh, who placed a Torpedo on a wet napkin, the shock was felt by five persons, who received it from a wire extending from one end of the napkin into a basin of water, and transmitted it by putting a finger of each hand in similar basins. There are two electric organs placed on each side of the head and gills. They consist of many perpendicular prisms, which are mostly hexagonal and form large flattened organs having the shape of kidneys. Each column in the living fish appears like a mass of clear trembling jelly. These cells occupy the thickness of the body between the dorsal and ventral covering. Hunter counted 470 columns in each organ, and says that the partitions between them are full of arteries which bring the blood direct from the gills. These organs appear to convert nervous energy into electricity. The nerves which extend through them are an electric branch of the trigeminal or fifth nerve, and four nerves which are branches from the side of the medulla oblongata, or hindermost part of the brain, each as thick as the entire spinal cord itself. These nerve trunks subdivide and penetrate into the partitions between the columns. It has been taken on many parts of the British coasts, but more frequently in the English Channel than elsewhere. Specimens taken in Cornwall have sometimes weighed a hundred pounds, but usually they weigh only half as much. An example which weighed forty-five pounds was forty-one inches and a half long by twenty-nine inches and a half broad, but on the following day its dimensions had altered to forty-two inches by thirty, though it then weighed only forty-three pounds and a half. After death the plump appearance of its upper surface is lost, and the lower border curls upward. It is usually taken in the trawl, but sometimes with the line. The colour is a dark brown, which is lighter round the eyes. The specimens which occur in the Mediterranean are usually

THE TORPEDO MARMORATA.

spotted. The teeth carry little barbs, rising from an expanded base. The mouth is small, and the jaw-bones slender. The nostrils are closer to the sides of the mouth than is usual with the Rays. The eyes are small, deeply imbedded, and directed upward. The spiracles are small and oval, and placed directly behind the eyes. The intestine is remarkably short, being less than half the length of the stomach. All the animal's movements are slow, and it prefers soft and muddy ground. Pennant remarks that it is eaten on the coasts of France, but Galen believed that when used as food the person eating it became stupid and dull. In the Middle Ages it was often prescribed for the cure of headaches. This species is distributed throughout the Mediterranean, and is found all over the eastern part of the Atlantic and the Indian Ocean. There is a second British species (*Torpedo hebetans*), which also occurs in the Mediterranean and adjacent parts of the Atlantic. It has the ventral fin more rounded, and separated from the pectoral fin, and has the body of a dark chocolate-brown above, and white on the under side. There are four other known species of the genus Torpedo, which frequent the Red Sea, the east coast of Africa, and the Mediterranean. The five other genera of this family all frequent tropical and sub-tropical seas, and are widely distributed on both sides of America, and range as far north as Japan, and as far south as Australia.

The genus Narcine has the tail longer than the disc, and has the spiracles immediately behind the eyes. The teeth, which are almost flat, sometimes are marked with a median point. There are four species. In tropical America *Narcine Brasiliensis* is met with penetrating into fresh waters.

The genus Hypnos has a remarkably short tail, body entirely naked, and tricuspid teeth with slender points. Only one species is known, which has minute eyes. The upper part of the body is black, and sometimes spotted with white. It is found only in the Australian seas.

Discopyge is another genus with the body entirely naked, but the tail is better developed and distinct from the circular disc. The teeth are flat. The ventral fins are united, and the vent is in the middle of the length of the body. Only one species is known from the coast of Peru.

Astrape has pointed teeth, and only one dorsal fin on the tail. There are two species of this genus.

Temera is a genus which differs from Astrape only in having entirely lost the dorsal fins, and in having blunt teeth.

FAMILY IV.—RAJIDÆ (THE RAYS).

The family of Rays is distinguished by having a broad rhombic disc formed by the pectoral fins extending to the snout. The skin is covered more or less with spines, which are short and sharp, and have a broad thick base. The electric organ is absent, and the tail never carries a bony spine. There are four different genera, which have these characters in common, but three of them are only known from single species, and are limited to the seas of India and China and the southern coasts of South America. In the genus Raja the tail is always well distinguished from the disc. The caudal fin is either absent or but very slightly developed. The teeth may be either blunt or pointed, but, like the dermal spines, differ in form with sex. The number of species in our own seas has probably been over-estimated, and may not exceed eight, though most authors enumerate a dozen; and altogether about twenty-five species are known from various parts of the world. The True Skate of the British fishermen (*Raja batis*) is one of the most abundant fishes of the British coasts. It is found almost everywhere in the south, and has been taken as far north as the Orkneys. It ranges round the shores of the German Ocean, and attains a large size. A stuffed female in the British Museum is five feet and a half broad and six feet and a half long. A specimen weighing 200 pounds was on one occasion dressed by the cook of St. John's College, Cambridge, and found sufficient for 120 members of that society who sat down to table. When caught in the Mediterranean it is valued as a delicacy, and in Schleswig-Holstein it is salted and dried for the German market. The fishermen of the southern coast of England esteem it chiefly for bait, since when stale it is always successful with Lobsters and Crabs. When caught on the hook it is almost impossible to raise it, as the animal usually lies still and keeps its head down, but when once the head is raised the fish rises in the water like a kite in the air. In the breeding season Bloch declares that each female is followed by several males. The purse in which the eggs are contained has an oblong shape, and a length of four or five inches. The eggs are dropped in pairs, and left to take their chance of development, and if dropped near to shore they are often washed up on the beach in rough weather. They are most

easily taken when the hooks are baited with Pilchards or Herrings, though one kept in captivity by Sir John Dalyell would feed on nothing but Whiting. Couch records that in the stomach of one animal he found a Fishing Frog that weighed six pounds, in another two large Plaice, a Lobster, a couple of Mackerel, a Thornback Ray eighteen inches long, and half a Salmon. The colour of the upper part of the body is dusky grey or mottled, and its colour has caused it to be known in Scotland in some places as the Grey Skate, and in others as the Blue Skate. At Lyme Regis it is called the Tinker. The females are always called Maids. This species is frequently infested by the Fish Leech, *Hirudo muricata.*

THE LONG-NOSED SKATE.*

The Long-nosed Skate has the snout prolonged to a sharp point far in advance of the mouth. The anterior outlines of the body are concave. Its usual size, according to Couch, is four feet seven inches long, with a breadth of a little over three feet; the tail measures sixteen inches. The body is of a lead colour, greatly flattened and smooth. On the under side it has dark spots similar to those of the Common Skate. The skin is smooth, but the tail is rough and armed on each border with a row of large recurved spines, but is without any spines in the median line. The teeth are sharp, but closely packed together on a semicircular curved surface of the bone, and in the upper jaw form forty-six rows. In the young the teeth in both sexes are flat, but as the male acquires age his teeth towards the centre of the mouth become elevated, keeled, and pointed. The females are larger than the males. The eggs are deposited in the latter part of the spring or summer in the usual purse-like cases. In London Skates are generally brought to market in autumn and winter, since the flesh becomes soft and woolly during the breeding season. The species is caught in deep water, and is always violent on the hook, but a large number are taken in trawl-nets. It ranges all round the shores of the North of Europe.

THE BORDERED RAY.†

In this fine species the anterior outlines of the body are deeply undulated, and the snout contracts rapidly into a slender forward process. The posterior outlines of the body are relatively short, so as to give the disc a triangular appearance. The body is smooth above, but the tail has a median row of spines, and there are stronger lateral rows on each side. This species is very much thicker and heavier than the Common Skate, and is frequently eight feet long, and a little broader. The colour is grey above and white below. The claspers of the male are long and stout. The adult animal frequents deep water, and is taken only in summer and autumn. It is in great demand in France, and during Lent the French fishermen come to Plymouth and the south coast of England to purchase this species, which is covered with wet sand to keep it fresh during the run back to France. In Scotland it is known as the White Skate; in Cornwall as the Burton Skate. It has been taken as far south as Madeira, but is characteristic of the European coasts.

THE SHAGREEN RAY.‡

This Ray has a double series of strong spines on the upper surface of the tail, but none in the median line, except a short series in the middle of the back. There are spines arranged in semicircles like eyelids between the eyes; the anterior borders of the body are undulating, much as in *Raja marginata.* In both sexes the teeth are slender and in the upper jaw are arranged in about sixty rows. The body is covered with minute spines both above and below, and these have secured for it the name of Shagreen Ray. It is a species of moderate size, being about two feet eight inches long, and one foot two inches broad; it is often taken in the North of England and Scotland, and is said to feed on small Star-fishes and various kinds of crustacea, but has been taken on hooks baited with the Sand-eel. Its flesh is soft and dry, so that it is less sought after for food than some of the other species.

THE HOMELYN RAY.§

The Homelyn Ray is a smooth-skinned species which has the body of a sub-pentagonal form. There is a median series of spines running along the middle of the back and tail, and usually lateral series also along the tail, which are absent from the back. This species is very variable in its ornament,

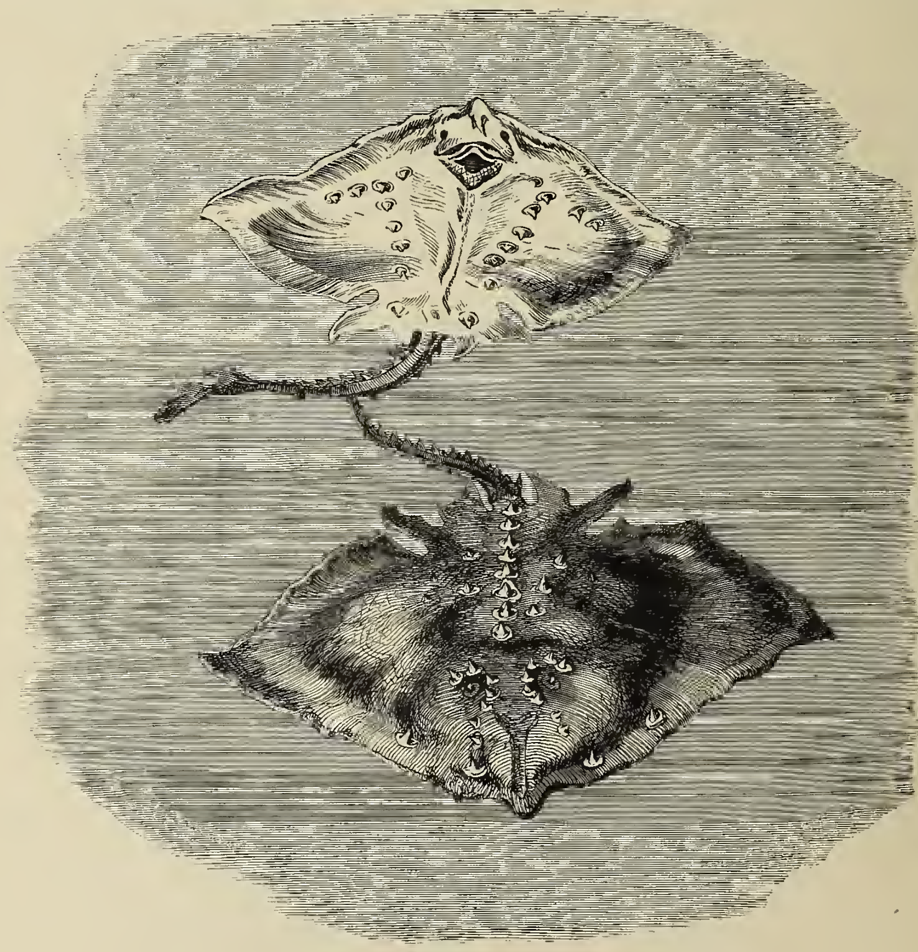
* *Raja vomer.* † *Raja marginata.* ‡ *Raja fullonica.* § *Raja maculata.*

and hence is sometimes known as the Spotted Ray and as the Painted Ray. It is found nearer into shore than the Thornback, and deposits its eggs, which are smaller than those of the Thornback, in shallow water, so that they are often thrown on the beach in stormy weather. The young are hatched from November to January, and then have a breadth of three inches and a length of five inches, half of which is formed by the tail.

Closely allied to this British species is the Sandy Ray (*Raja circularis*), a variety of which, known as the Cuckoo Ray, has usually only two large spots on the back, while the *Raja circularis* has from eight to sixteen small spots, each about the size of a pea.

THE THORNBACK.*

The Thornback is one of the commonest of British Rays, and is taken all round our shores, on the Dutch coast, and along the Mediterranean Sea as far as the Golden Horn; and it is also met with at Madeira. It is of a dark-brown colour, with fainter-coloured spots. The whole upper surface



THE THORNBACK.

is covered with asperities, and a variable number of large spines like recurved nails, which are more abundant in the female than in the male, but always extend down the tail in a median line. In spring and summer it is taken abundantly, because it then comes into shallow water to deposit its eggs, but is in the best condition for table in November, though the flesh is firm throughout autumn and winter. It is a favourite food with fishermen, and is frequently salted; but in the Moray Firth

* *Raja clavata.*

it is preserved by pressure, large stones being heaped over the fishes to squeeze out the juices of the body, after which it is only necessary to secure the flesh from rain and moisture. The quantity taken depends a good deal upon the bait; the Pilchard and Herring always attract it, but it feeds on Crabs and other Crustacea, and according to Yarrell also upon Flat-fish and Mollusca. A specimen three feet two inches long was twenty-eight inches broad, and had the tail a foot and a half long. The teeth are rather large, but, like the spines and asperities, differ in character in the female and male. In the former all the teeth are flat, but in the latter the middle teeth are conically pointed. Nearly allied to this species is the *Raja radiata*, in which the large spines on the back attain greater dimensions than in the Thornback, and rise from an expanded base; the largest spines are in the middle line of the back and tail, and above the eyes. The shoulder-girdle of the Thornback is a nearly perfect girdle formed at the sides by the scapula and coracoid, with the ring completed by the epicoracoids below, and the supra-scapulæ above, which latter bones abut against the spine of a neck vertebra.

In Psammobatis, which frequents the southern coasts of South America, the disc is perfectly circular and only five inches wide, the snout being very short. Each ventral fin is divided into two by a deep notch; the anterior portion is covered by the pectoral fin. Each nostril has two nasal valves. The tail is three inches and a half long.

Platyrhina has a well-developed caudal fin, and is represented by two species from India and China, which both have the disc nearly circular.

FAMILY V.—TRYGONIDÆ, THE STING RAYS.

The Sting Rays form a large family, about twenty-four species of the genus Trygon being known, chiefly from tropical and sub-tropical seas, while the family includes, according to Dr. Günther, several nearly-allied genera, such as Urogymnus, Tæniura, Urolophus, and Pteroplatea. The common Sting Ray,* like all the members of its genus, has the pectoral fins prolonged forward so as to unite in front of the head, while the tail is armed in its middle portion with a sharp, flattened, bony spine, serrated on both sides like a double-edged saw or harpoon. The spine projects upward and backward, and has the serrations hardened by an outer dense layer, so as closely to resemble tooth-structure. When the dart has become worn out its attachment to the body is loosened, and after being cast off another one grows in its place. Occasionally the new spine protrudes from under the old one, which may be seven inches long in a fish measuring three feet. This fish was well known to the ancients, and regarded with dread on account of the supposed poison of its spine. It lives on shallow, sandy ground, rarely takes the bait, and is commonly caught by accident in nets. The flesh, when laid bare by skinning, is more than usually red, and is said to have a rank flavour. The species is comparatively rare on the British coast, but has a remarkably wide range being found in the Gulf of Mexico and on the northern coasts of South America, in the Canary Isles, and on the shores of China and Japan. *Trygon hystrix*—a species frequenting the Brazilian coast—was taken by Mr. Bates, at Santarem, on the Amazons. *Trygon tuberculata*, a species which has the tail twice as long as the body, ranges from Sydney to the tropical parts of the Atlantic, and yet occurs in Lake Champlain. *Trygon hastata*, from New York, has the tail armed with two spines placed at a distance from each other. *Trygon rudis*, from Old Calabar, has the body six feet and a half broad, by four feet and a half long, while the tail measures fully six feet more. Usually the plates which carry the teeth are straight, or but gently undulating, but in the *Trygon sephen*, a species met with in the Indian Ocean and the Red Sea, the upper jaw is angularly bent, and receives the lower jaw—which is necessarily somewhat pointed—within this concavity. Rarely Trygons occur which have the body almost or entirely smooth, such as *Trygon nuda*. The longest-tailed species is *Trygon uarnak*, which has the body three feet long, with a tail nine feet long. The genus Tæniura is represented by six species, some of which are found in the East Indian seas, and others in the fresh waters of tropical America, *Tæniura motoro* being found in the River Cuyaba, in Brazil. Urolophus is a genus represented by five species, some of which are confined to the Australian seas, and others, like *Urolophus torpedinus*, are found in the West Indies and on the Pacific coast of Central America. In this genus the tail has a distinct terminal fin, with rays. The genus Pteroplatea has the body at least twice as broad as long, and the tail very short and

* *Trygon pastinaca.*

thin. There are half-a-dozen species from all the tropical and sub-tropical seas. The well-known *Pteroplatea altavela* occurs in the Mediterranean and on both sides of the Atlantic. Dr. Günther includes two genera in this family which want the bony spine on the tail. One of these—Ellipesurus—from the Rio Branco, in British Guiana, has the tail very short, and distinct from the nearly circular disc. The other genus—Urogymnus—has a long tail, and a body densely covered with osseous tubercles. It is known only from the Indian Ocean.

FAMILY VI.—MYLIOBATIDÆ, THE EAGLE RAYS.

The Eagle Ray* is so named on account of the broadly-expanded pectoral fins, which closely resemble wings. The head projects well in front of them; the tail is twice as long as the body, and slender like a whip, and immediately behind the dorsal fin carries a doubly-serrated spine. The eyes are placed so as to look laterally, and have been compared to those of an ox. The colour of the body is greenish or brown, and the skin is smooth. The palate consists of a succession of transversely elongated teeth, margined at the sides with smaller teeth. Specimens of the fish in the British seas have been estimated to weigh three hundred pounds, but the species is rarely taken. In the Mediterranean it is much more abundant, but the flesh, though sold in the Italian markets, is not held in great favour. Eagle Rays have been seen swimming on the surface of the sea, as have many other species of the same group, and they appear to breast the tide without difficulty. It is probable that the species is widely distributed, since it has been taken in the neighbourhood of Sydney, on the Australian coast. All the other species of the genus occur in Eastern seas, especially those of China, Japan, and the Indian Archipelago, though the *Myliobatis bovina* appears to be limited to the Mediterranean and adjacent parts of the Atlantic. In two species, both known from young specimens, the caudal spine has not been observed, and Couch records that it had not yet appeared in an embryo which he found still contained in the purse. He describes the purse in the British species as six inches and a half long and four inches and a half broad, with tendrils at the corners which were seven inches and a half long, and ended in a slender cord. The surface of the purse was marked with closely-set raised longitudinal lines, which were crossed by other lines and raised points. Towards the corners the reticulations form squares. The purse is nearly black. There are two other genera in this family—the Actobatis, which is distinguished by having broad, flat teeth, like those of the middle series of Myliobatis, without any lateral teeth, and Rhinoptera, which has no large median teeth, but has the jaw covered with polygonal plates, like a tesselated pavement.

THE OX RAY, OR SEA-DEVIL.†

The Ox Ray, or Horned Ray, differs from other Skates in having two processes prolonged forward from the pectoral fins, like horns. Its pectoral fins are even more expanded than those of the Eagle Ray, but on the other hand its tail is extremely short, and the dorsal fin is placed upon the hinder part of the body. It is brown above and white below. Its home appears to be in the Mediterranean, though specimens have been taken on the coast of Ireland. The flesh is red, dense, and difficult of digestion, but is eaten by the poor. In the Mediterranean, examples have been captured twenty-eight feet wide and twenty-one feet long, though this was said to be the smallest of a shoal. The fish was estimated to weigh a ton. The mouth is wide enough to swallow a man. The females are said to be larger than the males, and darker in colour. The young are produced in September, from eggs contained in long yellow cases. The species feeds chiefly upon cephalopods and fishes, and has been taken in nets arranged to catch the Tunny. The liver is large, and yields a quantity of oil. Dr. Günther describes the teeth as minute, extending nearly to the angles of the mouth, and arranged in more than a hundred and fifty rows. The number of rows of teeth is distinctive of the species. One with forty rows in the upper jaw occurs on the coast of Brazil, and others with from thirty-four to ninety rows occur in the Indian seas, and one species ranges to Japan. In the nearly-allied genus Ceratoptera—which differs in having the teeth developed in the lower jaw only—an equally large size is apparently attained, for the *Ceratoptera vampyrus*, which frequents the Atlantic and Gulf of Mexico, attains a width of twenty feet. A specimen fifteen feet wide, and as long, was between three and four feet

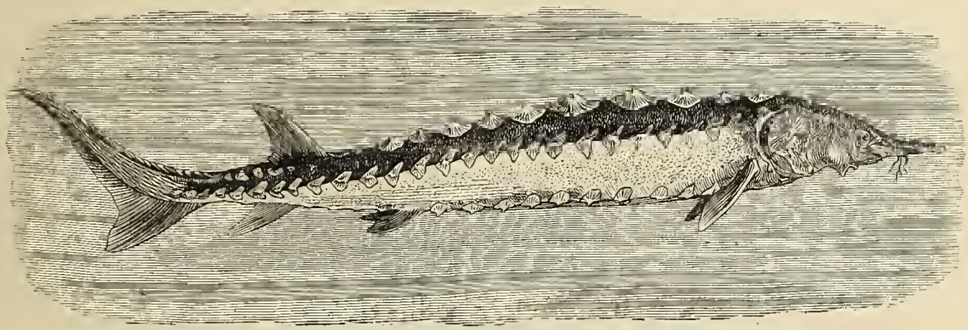
* *Myliobatis aquila.* † *Dicerobatis giornæ.*

thick. It contained an imperfectly-developed young one, which was five feet broad, and weighed twenty pounds. A second species of the genus is recorded from the Red Sea.

ORDER V.—CHONDROSTEI.*

STURGEONS.†

The Sturgeons form a small and natural group of fishes, distinguished by having a cartilaginous skeleton. They have the head covered with bony plates, and the body armoured with five rows of bony bucklers, or scutes, which give it an angular character. The snout is pointed and conical. The mouth opens in a large but short tube below the eye on the under side of the head, and is destitute of teeth. Both jaws are formed of two cartilages, covered with a thin layer of bone. There are only two genera of Sturgeons known. Nineteen species belong to the genus *Acipenser*, while the second genus, called the Shovel-head (*Scaphirhynchus*), is represented by a single species (*S. cataphractus*), found in the Mississippi and its tributaries. It differs from the other Sturgeons in wanting spiracles, and in having the bony scutes uniting with each other on the hinder part of the tail, so as to envelop it in continuous armour. The nostrils in Sturgeons are double, and placed in front of the eye, and there are four barbels arranged in a transverse series in front of the mouth on the under side of the snout. There are no bony rays for the support of the gills, but there are four



THE COMMON STURGEON.

true gills and two accessory gills. The dorsal and anal fins are placed near to the caudal fin, which is unequally lobed or formed on the heterocercal plan usual among Sharks. Where the skin is not covered by the bony plates it is soft and covered with pores, which secrete mucus. The Sturgeons swim low, and feed on the decaying substances, animal and vegetable, which sink to the bottom of rivers and estuaries. These fishes have always been valued for their roe, which is known to us under the name of caviare. The eggs are deposited without being contained in cases, much in the same way as the eggs of bony fishes. A specimen which weighed 273 lbs. had the roe weighing 42 lbs., and in this there were computed to be two millions of eggs.

The life of the Sturgeon has been observed only after it has ascended rivers. It moves along with a gentle motion which suggests crawling rather than swimming, stirring up the mud and sand with its snout seeking for food. In the breeding season some species feed almost exclusively on small fishes allied to the Carp. They travel along the rivers between March and the latter part of autumn, but hibernate during the winter. Caviare is prepared from the roe in a very simple way. Usually it is beaten up and passed through a sieve to separate the eggs from the tissue in which they are contained. Salt is then added, and the eggs are packed in barrels for exportation. Another method of preparation is to remove the larger filaments of connective tissue, then salt, and dry in sun; it is next forced into barrels with the pressure of the feet. Better caviare is made by salting the roes in long troughs. They are then placed in fine sieve troughs, while the eggs are pressed through into small kegs. The best is obtained from the *Acipenser stellatus* and *Acipenser ruthenus.*

The fishing in winter is carried on, according to Brehm, in a singular way. The rivers are frozen over; and the fish which have hibernated bury their snouts in the mud so as to leave the

* *Chondros*, cartilage, and *osteon*, bone. † *Acipenseridæ.*

bodies sticking up in the water like the piles of a Swiss lake dwelling. The fisherman is armed with a pole, which is from twenty to sixty-five feet long, and terminates at one end in an iron rake. This instrument is put down through a hole in the ice, and the Sturgeon is speared. When one is caught the pole vibrates in the fisherman's hands, and he brings his capture to the surface. Sometimes days pass without a fish being taken, but often as many as ten may be landed in a day. On the Ural River 4,000 Cossacks in two hours have taken 40,000 roubles' worth of fish.

In summer fishing a portion of the river is hired from the landowner by the fisherman. He engages assistants, who may be Russians, Greeks, Tartars, Moldavians, or Poles, and provides boats and all requisites for the work, and builds large huts roofed with rush for the accommodation of his people, as near to the river as may be, but so placed as to escape floods. Each hut sleeps about twenty men. Salt is there stored in barrels, and mills are set up to grind it. The fish are captured in nets. If fishing is successful the men fare well; but usually their meals are of fish. A mast is set up on the bank with a look-out at the top, and here a man is placed to watch and give notice when the Sturgeon are seen coming up the river. Though often met with in the sea, the Sturgeon ascends rivers to deposit its eggs. Their numbers in many of the Russian rivers are almost incalculable. At Ruibinsk, on the Volga, in the Russian government of Yaroslav, the fisheries draw together in spring and summer a hundred thousand people, who work continuously, and disperse to their homes in winter. When the fishing has been intermitted for a day the Sturgeons have been known to completely fill a river 360 feet wide and 28 feet deep, so that the uppermost fishes appeared with their backs above the water. Fifteen thousand have been taken in a single day. They occur in incredible multitudes in the Caspian, and are numerous in all the rivers of the south of Russia.

The Sturgeon is also valued for its air-bladder, which is a large simple bag that opens into the gullet. This is believed to enable the fish to vary the quantity of air which it contains, so as to influence the density of its body. The air-bladder is converted into isinglass. After being washed the bladder is turned inside out and dried. The internal membranes are then easily detached. It is again moistened and hung in the shade, and afterwards cut into strips, which are stretched on the bark of a tree to dry. The best isinglass is yielded by the Sterlet and by *Acipenser huso.* The Common Sturgeon of our own seas (*Acipenser sturio*) is widely distributed over the world, being found throughout the Mediterranean and all round the western and northern shores of Europe, and along the eastern coast of North America. It is frequently taken in the Thames, but does not often reach a greater length than eight feet. A specimen eight feet six inches long, taken in the Findhorn, in Scotland, weighed 203 lbs. Pennant mentions an example caught in the Esk that weighed 460 lbs. In the Rhine it sometimes ascends to Mainz, and occasionally reaches Basel. It is also found in the Weser, Elbe, Moldau, Oder, and Vistula. The flesh is white and firm, and has a flavour that may be described as combining that of veal and lobster. It is often salted and preserved for winter use. Though an excellent fish, it never commands a high price in the London market. Yarrell mentions that the stomach of one caught in the Tay was found to contain an entire sea mouse, the *Aphrodita aculeata.* Couch expresses an opinion that worms are probably their favourite food, but quotes a statement from an American newspaper that a lady's riding-whip, mounted with silver and twenty-one inches long, had been found in the stomach of a Sturgeon of moderate size. The snout is pointed. The barbels vary in position, being sometimes in front of the middle line between the eye and the end of the snout, and sometimes behind it. The dorsal shields, which are large, extend in the middle line of the back between the head and the dorsal fin. The lateral shields are as few as in any known species, varying from twenty-six or twenty-seven in young specimens, to twenty-nine or thirty-one in the adult. The skin is rough, with small star-shaped ossifications, which are arranged in more or less regular oblique series.

The *Acipenser huso* is a larger fish than the Common Sturgeon, reaching a length of twenty-five feet and a weight of 1,200 lbs. Its appearance is smoother than the Common Sturgeon, for though it also has five rows of angular scutes, extending down the body, each plate is smaller. There are about a dozen dorsal shields and forty to forty-five lateral shields. Some of the larger specimens have been found, according to Shaw, entirely destitute of armour, and with the skin smooth and slimy, so that the plates appear to drop off in old age, much as the hair sometimes drops off in man. The snout is short and three-sided, of a yellowish-white colour. The upper side of the body is dark

grey, but the plates are dirty white, like the under-side of the body. The barbels are flattened, and nearer to the eye than to the end of the snout. It is only occasionally found in the Mediterranean, and is otherwise confined to the Black Sea and Sea of Azov, and the rivers which flow into them.

The *Acipenser ruthenus*, commonly known as the Sterlet, is a small species, rarely more than twenty-one inches long. It has a narrow, pointed snout, which is somewhat clongated. The barbels are slightly fringed. The number of dorsal shields varies from eleven to fourteen. The lateral shields are more numerous than in any other species, and are from sixty to seventy in number. The skin is densely covered with minute ossifications, which are uniform in size. The back is a very dark grey, but the shields are whitish like the belly. It is found in the Black Sea, and in all the rivers which flow into it. It is a regular article of food at Vienna, is sometimes taken at Linz, and occasionally ascends as far as Ulm. It is abundant in the Caspian and the rivers that empty themselves into it; but less plentiful in the rivers of Siberia. It is believed to extend into the north-west coasts of America. *Acipenser ruthenus* deposits its eggs when the water has a temperature of 54° Fahr. The eggs are sometimes fecundated artificially in the Volga. The young are developed in seven days. They are at first a quarter of an inch long, but in ten weeks increase to a length of two inches, feeding chiefly on the larvæ of insects. They can live in fresh water only, but are hardy, and are often transported overland. In this way it was introduced long ago into Pomerania and Sweden. Several different species, distinguished by the form of the snout, the number of osseous shields, and the rays in the dorsal fin, occur in California, the Mississippi, and great lakes of North America. Other species are confined to the Atlantic coast of the United States. Sturgeons, however, are not found in North America north of latitude 54°, where the mean annual temperature is 33° Fahr. They are not often seen in clear cold streams, but make their way up many muddy rivers in such numbers as to form almost the only food of the Indian tribes during the summer months. The *Acipenser brevirostris*, which is usually from two to five feet long, is so abundant in the river Hudson as to be known in the markets under the name of Albany beef. One species (*A. Sinensis*) is known only from China, and is reserved for the table of the Emperor. Two or three species appear to be limited to the Mediterranean, but the majority of Sturgeons are confined to the Black and Caspian Seas, and the rivers which flow into them.

A second family in this order is formed for the Paddle-fish genus, named *Polyodon*. It is represented by two species, one (*Polyodon folium*) found in the Mississippi and its tributaries, the other (*Polyodon gladius*) occurring in the Yang-tse-kiang. The genus differs from the Sturgeons in having the skin naked, or containing only minute star-shaped ossifications. The snout is extremely long and shovel-like. It is covered with small star-like reticulations, and is regarded by Wagner as being a forward prolongation of the parietal region of the skull. The maxillary arch is fixed to the head, so that the mouth cannot be protracted as among the Sturgeons. The jaws are armed with minute teeth, and there are teeth on the palatine bones. There are no barbels, and there is no tongue, so that the sense of touch must be feeble. The fins resemble those of the genus Acipenser, except that the lower lobe of the caudal fin is nearly as broad as the upper lobe. The air-bladder is large and cellular, and opens into the œsophagus. There is hardly any separation between the œsophagus and the stomach; the pancreas is a short broad lobed organ; and the intestine terminates in a spiral valve. The cartilaginous rings of the vertebral column are more delicate than those of the Sturgeon.

CHAPTER III.

THE PLECTOGNATHI.—THE LOPHOBRANCHII.—THE ANACANTHINI.

THE PLECTOGNATHI—Singular Shapes of the Fishes of this Order—Their Characters—The Triacanthinæ—The Balistinæ—The File-fish—The Monacanthinæ—The Ostracion—The Gymnodontes—The Genus Triodon—The Globe-fishes—The Genus Xenopterus—The Tetrodons—The Genus Diodon—Darwin on the Habits of a Diodon—Allied Genera—The Sun-fishes—The Common Sun-fish—Habits—Characters—The Oblong Sun-fish—THE LOPHOBRANCHII—Their distinctive Features—The Solenostoma—Characters—The Syngnathidæ—Interest attaching to them—The Broad-nosed Pipe-fish—Description—The Great Pipe-fish—Habits—The Marsupial Pouch—Other Species—The Ocean Pipe-fish—The Worm Pipe-fish—The Sea-horses—Phyllopteryx—Dr. Günther's Account of its Spines and Filaments—The Genus Hippocampus—The British Sea-horse—Other Species—THE ANACANTHINI—THE COD-LIKE DIVISION—THE COD—Its Voracity—Its Fecundity—Tame Cod—Description of the Fish—The Cod-fisheries—Long-line and Hand-line Fishing—THE HADDOCK—A "Great Conchologist"—"St. Peter's Mark"—THE WHITING—Couch's Whiting—The Pollack—The Coal-fish—THE HAKE—The Greater Fork Beard—The Burbot—THE LING—THE MACKEREL MIDGE—The Silvery Gade—The Rocklings—The Tadpole Hake—THE TORSK—The Ophidiidæ—Characters—THE GENUS FIERASFER—Distinctive Features—The Greater Sand Eel—The Lesser Sand Eel—THE FLAT-FISH, OR PLEURONECTIDÆ—Characters—THE HOLIBUT—The Largest of the Flat-fish—The Rough Dab, or Sand-sucker—THE TURBOT—THE BRILL—THE WHIFF, OR MARY SOLE, OR SAIL-FLUKE—The Topknot—BLOCK'S TOPKNOT—The Scald-fish, or Megrim, or Smooth Sole—The Genus Pleuronectes—THE PLAICE—Favourite Fish of the Poor—Lacépède's Story about Shrimps and Plaice—THE DAB, OR SALTIE, OR SALT-WATER FLUKE—The Smear Dab—The Pole, or Craig Fluke—THE FLOUNDER—THE SOLE—THE LEMON SOLE—THE VARIEGATED SOLE—The Solenette—Trawl Fishing.

DIVISION II.—TELEOSTEI (BONY FISHES).

ORDER I.—PLECTOGNATHI.

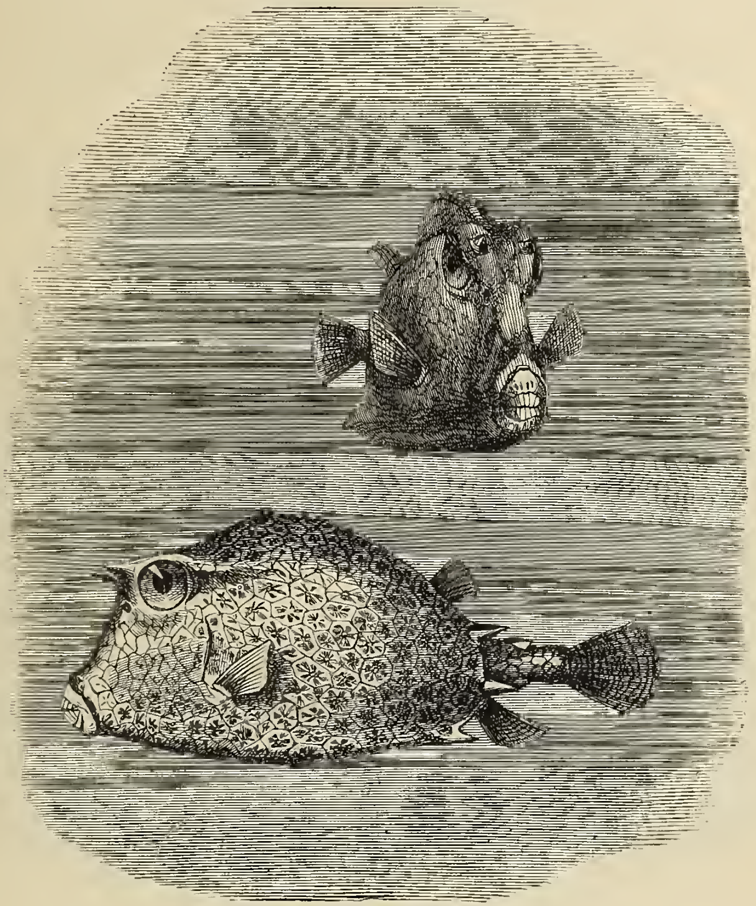
THE fishes which belong to this order present some of the most singular shapes which are known. The skin is sometimes covered with ossifications in the form of spines projecting all over the body, as in the Globe-fish; or it frequently, as in the genus Ostracion, forms a carapace, or bony box built up of scutes, which rather suggest the shield of a leathery Turtle than the covering of a fish. Often the jaws are formed into massive teeth, as in the genus Diodon, which rather suggest the beak of a bird; while many, like the Sun-fishes, are short-bodied, and are constructed on principles of symmetry very different from those which are usual in the group. The internal skeleton is often imperfectly ossified, and the vertebræ are few. There are no ventral fins, or they are represented by bony spines, but there is a soft dorsal fin opposite to the anal fin, and both are placed in the hinder region of the body. The air-bladder is always present, but is never connected with the throat by a pneumatic duct. The form of the jaws serves to divide the order into two groups. The family in which they form a beak has been named Gymnodontes, while that in which the jaws possess distinct teeth, has been termed Sclerodermi.

FAMILY I.—SCLERODERMI.

This family, as the name indicates, has the skin more or less covered with scutes or roughened with spines, and the snout is somewhat prolonged in front. Dr. Günther divides this family into three groups, which are named from typical genera—Triacanthina, Balistina, and Ostraciontina. The first group includes in all but five species and three genera; one of these comes from Japan, another from Cuba, while the Triacanthus, with its three species, ranges through the Australian seas to the north of China. In all these fishes the skin is covered with strong and rough little scutes. The ventral fins are formed by a pair of strong spines, which are joined to the pelvic bone. The teeth have the form of incisors, and there is an anterior dorsal fin with a few small spines behind a strong and large one. The second group—Balistina—has the body covered with scutes which are adjacent to each other, but movable. The teeth in the upper jaw form a double series of incisors, and in the lower jaw a single series. The first dorsal fin is reduced to three spines, and the ventral fin to a simple osseous spike. There are two important genera in this group, Balistes, with twenty-six species, and Monocanthus, with forty-one species. These are essentially fishes of tropical and sub-tropical seas, and the species often have a remarkably wide range. The single British species of Balistes illustrates this distribution, since it is met with in the Mediterranean, Atlantic, and Pacific Oceans.

Balistes capriscus is rather a rare capture on the British shores, but has been taken indifferently in the north of Scotland, the west of Ireland, and the English Channel. It has been named, from the toothed character of its dorsal spine, the File-fish, and from its very singular appearance, the Pig-faced Trigger-fish, though the latter part of the name is derived from the way in which the second

dorsal spine locks into the first. One of the most remarkable characters of the genus is a soft smooth furrow in front of the eye. There are shields behind the small gill-openings, and the face is usually covered with scales similar to those which exist on the body. There are no spines or tubercles on the tail. Thirty-two scales extend between the dorsal fin and the vent. The ventral spine is movable. Dried specimens are always brown, but Yarrell records that the living fish is turgid blue. An adult specimen has a length of fourteen inches; young specimens are sometimes marked with dark-brown spots. Some of the Eastern species, like the *Balistes niger* and *Balistes bursa*, have a series of



OSTRACION QUADRICORNIS.

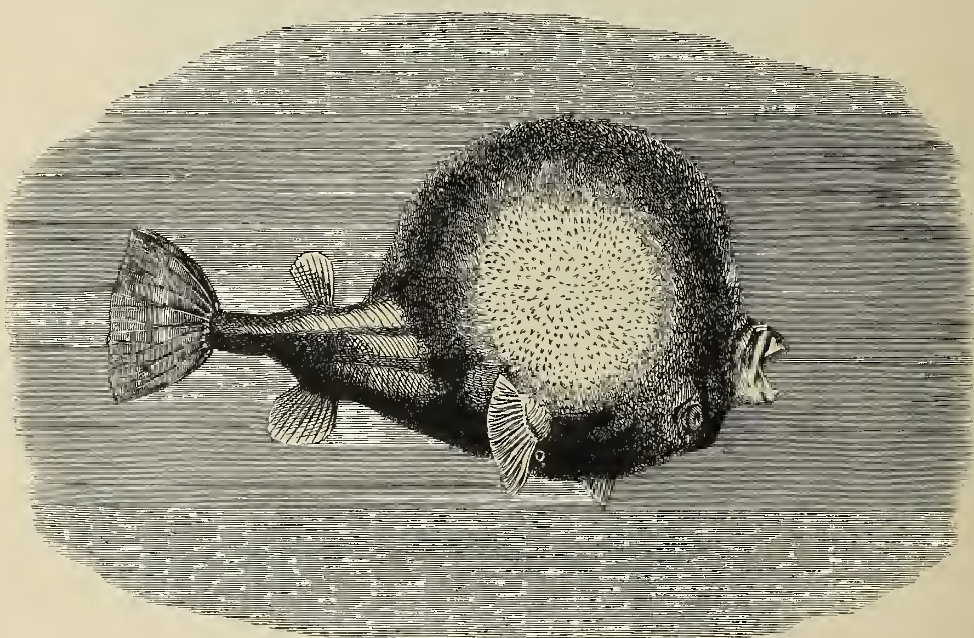
recurved spines on the tail. Other species, like the West Indian *Balistes ringens*, have longitudinal grooves on the cheeks. Several species have no groove in front of the eye, while the *Balistes erythrodon* has the teeth of a reddish-brown colour.

The genus Monacanthus has the body covered with very small rough scales. The ventral fin is usually fixed; the first dorsal fin is a single strong spine with a rudimentary spine behind it. In the *Monacanthus peronii*, and some other Australian species, the dorsal spine has four edges, which are at equal distances from each other, and each is barbed. In this species the spine is inserted above the middle of the orbit. The third group of the Sclerodermi contains only the Ostracion, which, however, is represented by about twenty-two species. These fishes are contained in a carapace formed of hexagonal plates which touch each other, but the snout, bases of the fins, and hinder part of the tail are covered with soft skin. The ventral fins do not exist. The maxillary and pre-maxillary bones have become blended together, and the jaw carries a single series of small teeth. There are only

fourteen vertebræ, the earlier ones elongated and the last five greatly shortened. The species are grouped into two sections—first, those in which the carapace is closed behind the anal fin; and secondly, those in which the carapace is open behind the anal fin. In some species the carapace has three longitudinal ridges, in others there are four, five, or even six ridges. Sometimes there are prominent spines which are conical, and project in front of the orbits, or from the ventral, or dorsal, or lateral ridges. None of these fishes attain a large size, the *Ostracion cubicus* having a length of fourteen inches, and the *Ostracion quadricornis* reaching a length of sixteen inches. *Ostracion bicaudalis* is seventeen inches long, but the *Ostracion renardi*, from Amboyna, is only about four inches long, and there are many other species of about this size. Like the other genera in this family, the Ostracion is most abundant in the Malay Archipelago, the West Indies, and tropical coasts of Africa. Two specimens of the *Ostracion quadricornis* have been taken near Mervagissey, on the Cornish coast.

FAMILY II.—GYMNODONTES.

This family, in addition to having a sharp cutting beak without teeth, formed of the bones of the fore part of the head more or less blended together, has the dorsal, anal, and caudal fins soft and approximating towards each other. The ventral fins are absent, but the pectoral fins are present. The



TETRODON FAHAKA (FLOATING BELLY UPWARD).

first genus of this family, Triodon, is so named because the upper jaw is divided by a suture in the middle, while the lower jaw is entire, thus giving the aspect of three teeth, which are large, white, and have the appearance of being powerful cutting organs. The eye is large, being about one-fourth the length of the head. The nostril has two distinct openings on each side of the head. The most distinct characteristic of this fish is furnished by the abdomen, which is capable of being dilated into a large sack which hangs below the body. The air, however, does not penetrate into its lower part, and the sack is kept expanded by a very long pelvic bone. This fish is found widely distributed in the Indian Ocean, and reaches a length of twenty-one inches. The skeleton is well ossified and the ribs well developed, and the body is covered with small bony plates which are spiny.

The second group has Tetrodon for its type, and though called *Tetrodontidæ* only, has both jaws divided in the two genera Xenopterus and Tetrodon, while the remaining six genera resemble Diodon in having no median suture in the jaws. These fishes are popularly known as Globe-fishes, from the well-known circumstance that after filling the body with air they float on the surface of the water

with the belly upward. Xenopterus is a genus of the Indian Archipelago, distinguished by its funnel-shaped nostril, and the small dermal ossifications which each have two or three roots, and form spines over the skin. The *Xenopterus modestus*, which is about four inches long, is found in the rivers of Borneo and Sumatra, but the *Xenopterus naritus* has been met with indifferently in rivers and the Sea of Penang. The specimens from Borneo reach a length of eleven inches.

The large yellow *Xenopterus naritus*, which is found in the rivers of British Burmah, is considered to be excellent eating, but an allied genus (Tetrodon) from the Nile is known to be exceedingly poisonous. Dr. Day records that a species from Japan (probably a Tetrodon) is used for purposes of suicide, and that a law exists which prevents a soldier's son from entering the army when his father has terminated his days by feeding on this animal. The Tetrodons are generally reputed to be poisonous, but they are eaten by the Andaman Islanders, and the native doctors in Malabar prescribe them as a medicine.

The genus Tetrodon includes about sixty species, which are nearly all tropical, and by far the larger number are known from the Malay Archipelago and adjacent seas, though well represented on the African coasts. Several species inhabit fresh waters. In the first section of the genus the scutes form a continuous carapace round the trunk; the second group has a broad back and very prominent nasal organs situate on elevated papillæ, but there are no scutes forming a carapace. In many species the spines are limited to the belly; in others they occur on both the back and belly, but are absent from the sides. Some have the spines minute and invisible, so that the fishes are smooth to the touch; others, again, have no spines at all, but minute soft tubercles on the skin. A number of species have the back compressed into a keel, and in these the nasal organs are never prominent. *Tetrodon fluviatilis* occurs indifferently in the fresh waters and on the coasts of the East Indies. The little *Tetrodon erythrotænia*, two inches and a half long, is from the rivers of Amboyna and Celebes. The entirely naked *Tetrodon cutcutia*, four inches long, is from the Ganges. *Tetrodon fahaka*, which is one of the largest species, reaching a length of eighteen inches, occurs all up the Nile, in the Niger, and on the West Coast of Africa. The largest form, twenty-seven inches long, is the widely-distributed *T. sceleratus*, which ranges round the Indian Ocean and through Polynesia.

The only British species, *Tetrodon lagocephalus*, is also found on the south and east coast of Africa, as far as Mauritius. The back is a brilliant ultramarine blue; the belly and sides are silvery-white; while the fins and tail are brown. The abdomen is covered with spines from the mandible to the vent; each has four roots. The back is almost straight. The air-sac has a smooth internal surface, with two openings into the œsophagus, the first simple, and the hinder one valvular. One of these is probably used only to admit the air, and the other to discharge it. It has been found on the coasts of Cornwall and Ireland, the largest specimen being twenty-one inches long.

The genus Diodon differs from Tetrodon in little beyond the absence of the median suture from the jaws. The body is similarly covered with ossifications in the skin, each with a pair of lateral roots, and a stiff movable and erectile spine. The upper part of the body is usually dark and the lower parts white. The largest species (*Diodon hystrix*) is two feet to two feet six inches long. The four species are found in all the seas between the tropics, and all range to the Cape of Good Hope. There is no British representative of the genus. Mr. Charles Darwin remarks, in his "Voyage of the *Beagle*," as quoted by Mr. Yarrell :—"One day I was amused by watching the habits of a Diodon which was caught swimming near the shore. This fish is well known to possess the singular power of distending itself into a nearly spherical form. After having been taken out of the water for a short time, and then again immersed in it, a considerable quantity both of air and water was absorbed by the mouth, and perhaps likewise by the branchial apertures. This process is effected in two methods: the air is swallowed, and is then forced into the cavity of the body, its return being prevented by a muscular contraction which is externally visible; but the water, I observed, entered in a stream through the mouth, which was wide open and motionless; this latter must, therefore, depend on suction. The skin about the abdomen is much looser than that of the back, hence, during the inflation, the lower surface becomes far more distended than the upper; and the fish, in consequence, floats with its back downwards. Cuvier doubts whether the Diodon in this position is able to swim; but not only can it thus move forward in a straight line, but it can likewise turn round on either side. This

latter movement is effected solely by the aid of the pectoral fins, the tail being collapsed and not used. From the body being buoyed up with so much air the branchial openings were out of the water; but a stream drawn in by the mouth constantly flowed through them. The fish having remained in this distended state for a short time, generally expelled the air and water with considerable force from the branchial apertures and mouth. It could emit, at will, a certain portion of the water; and it appears, therefore, probable that this fluid is taken in partly for the sake of regulating its specific gravity. This Diodon possessed several means of defence. It could give a severe bite, and could eject water from its mouth to some distance; at the same time it made a curious noise by the movement of its jaws. By the inflation of its body the papillæ, with which its skin is covered, became erect and pointed. But the most curious circumstance was that it emitted from the skin of its belly, when handled, a most beautiful carmine-red and fibrous secretion, which stained ivory and paper in so permanent a manner, that the tint is retained in all its brightness to the present day."

There are five genera closely allied to Diodon. Chilomycterus possesses a species (*Chilomycterus geometricus*) which, though widely distributed in the tropical parts of the Atlantic, is found in Lake Champlain and several inland waters of the United States; but most of the species of this genus belong to the Indian Ocean and adjacent seas. In the genus Trichodiodon, which frequents the North Atlantic, the spines on the body are reduced to delicate hairs: an example in the Paris Museum has a length of thirty inches. In Trichocyclus the spines become elongated like bristles, and the dorsal and anal fins are entirely absent.

The third division of the Gymnodontes contains only the Sun-fish; and this group, represented by a single genus, is named, from its typical species, Molina. The Sun-fishes belong to the genus Orthagoriscus. The body is short and compressed, and covered with a rough or tesselated skin, which is not capable of being expanded as among the Diodonts. The air-bladder is absent, there is no pelvic bone, the ventral fins are wanting, and the vertical fins are all placed together at the hinder part of the body, and often are so arranged that the dorsal and anal fins seem but lateral lobes of the caudal fin.

The Common Sun-fish (*Orthagoriscus mola*) inhabits the open sea, and has been met with in many parts of the world in temperate and tropical waters. It is not uncommon in Australia, where it is valued for the quantity of oil which it yields. Every year a few specimens are taken during the warmer months on some part of the British coast, even as far north as the Orkneys. It is usually captured floating on the surface, when it appears languid and almost asleep, with its head projecting out of the water, but it is sometimes found lying on its side, and is then probably sick, though the fishermen regard this as an indication of continued fine weather. In this state it is not alarmed by the approach of the fisherman, though, when the opportunity offers, it makes its escape over the surface faster than a rowing-boat can follow. When laid hold of these fishes utter sounds which some fishermen have compared to the loud grunting of a hog. When anything approaches the eye-ball, the ball is drawn into the socket, and a membrane rises up from the base and covers it. The Sun-fishes appear to retain their vitality for some time out of water, for a specimen kept in a boat for half an hour, on being thrown back into the sea is said by the fishermen to have darted away like an arrow. Couch mentions, on the authority of a friend, that when cooked for the table it is good eating, and has much the flavour of the Common Crab, but in this country no use is made of it. Its food is variable, and the stomach has been known to contain seaweed, corallines, and barnacles, though nothing but mucus is usually found there. Sometimes the species reaches an enormous size. The largest British specimen known is seven feet nine inches long, and eight feet six inches deep across the fins, but the proportions change with age, and in very young examples the vertical diameter exceeds the length, while in older examples the depth is somewhat more than half the length. With age a hump is developed above the mouth, and on this there is a bony tubercle, while in very young specimens this position is marked with a spine. Young examples, too, have spines scattered over the body, and in the region of the throat some of these are converted into osseous tubercles, and remain throughout life. The teeth undergo a remarkable modification. In the young state there are supplementary teeth within the cutting jaws, and these teeth are generally met with till the fish attains a length of eighteen inches, but when the animal has become twice as long they have entirely disappeared. The head is thicker than the body, and has an elevated ridge above the eye. The small mouth is placed below the blunt nose, and is capable of but little movement. Each jaw has the

surface of the bone covered with enamel. The openings of the gills are small, nearly vertical, slits just in front of the pectoral fin. The vent is prominent, the dorsal and anal fins are triangular at the base, and greatly elongated; they join on to the caudal fin, which is narrow, and not very conspicuous, though it runs the depth of the body. The back and fins are usually almost black, but the belly is a brilliant white. Couch mentions that some small specimens have beautiful variations of colour in stripes, with blotches of blue, yellow, and white. The stomach is long and large, the intestine thick, and convoluted into a ball, and there is a large urinary bladder which communicates with large kidneys by two ducts. The Sun-fish is usually infested with parasites, which are found in the gills and on various parts of the skin.

The Oblong Sun-fish (*Orthagoriscus truncatus*) has the height of the body less than one-half its total length. The mouth is about level with the eye; the smooth skin is divided into small hexagonal scutes. A specimen taken at Plymouth in 1734 weighed 500 lbs., but it is not often met with of a large size. It lives on worms, sea-shells, crabs, and other marine animals. A young specimen twenty-five inches and a half long had the body twelve inches and a half deep, and the height, from the tip of the dorsal fin to the tip of the anal fin, was twenty-one inches and a half. On this specimen there were wavy vertical stripes both on back and belly; only on the back they appear as silver streaks on a dusky brown surface, and on the belly as greyish-brown streaks on a surface of silver. It has never been noticed basking in the sun like the Broad Sun-fish. The caudal fin is more distinct in this species, and the dorsal and anal fins form continuations from it. The pectoral fin, which in the Broad Sun-fish is rounded at the extremity, in this species terminates in a point. It is very rarely met with, but has been found in the English Channel, Bristol Channel, and the northern coasts of Scotland, and ranges along the west coast of Africa by Sierra Leone and the Cape Seas, and has been met with in the Pacific. A third species of Sun-fish (*Orthagoriscus lanceolatus*) is recorded from Mauritius. It differs chiefly from this in having the caudal fin as long as it is deep.

ORDER II.—LOPHOBRANCHII,* OR FISHES WITH TUFTED GILLS.

The most remarkable characteristic of this order of fishes is found in the form of the gills, for instead of being pectinated, or shaped like a series of combs, as in other fishes, they consist of small rounded lobes clustered together, so as more to resemble the appearance of minute mulberries, and yet are attached to the branchial arches. These gills are protected by a single large plate, which is the only representative of the operculum. The snout is produced into a tube, and ends in a small toothless mouth. The air-bladder, when present, is simple, without a pneumatic duct connecting it with the œsophagus, though in one species Dr. Günther has found a band leading from the œsophagus to the air-bladder, which probably indicates the former existence of a duct, which has become obliterated. There are only two families in this group, which are named Syngnathidæ, comprising the Pipe-fish and the Sea-horses, and the Solenostomidæ, which contains only the genus Solenostoma.

FAMILY I.—SOLENOSTOMIDÆ.

This family is distinguished by the great width of the openings into the chambers containing the gills, and by possessing two dorsal fins, with firm unjointed rays in the first fin, while all the other fins—pectoral, ventral, anal, and caudal—are well developed. These characters easily separate Solenostoma from the Pipe-fishes. Of Solenostoma only three species are known. The genus has a very simple intestine, dilated somewhat, so as to form a stomach, but without any appendages in the pyloric region, so that the function of the pancreatic secretion in assisting digestion must be rendered unnecessary by the nature of the food on which these animals subsist. The air-bladder is absent. The ventral fins, which are opposite the anterior dorsal, are free in the male, but in the female their inner margins are united with the covering of the body, so as to form a large pouch into which the eggs are received to be hatched. The inner walls of this sac are lined with long filaments, which are arranged along the seven ventral rays in series, and are most numerous at the base of the rays. There is a canal in the interior of each filament, which may furnish a secretion for the attachment of the embryo. The largest filaments have a length of half an inch, and are covered with little appendages like mammæ. The filaments are most developed in fishes which have already deposited

* *Lophos*, a tuft; *branchia*, gills.

THE BROAD-NOSED PIPE-FISH.

the minute eggs in the sac. The vertebral column consists of eighteen abdominal vertebræ and fifteen caudal vertebræ. The vertebræ gradually decrease in length backward, so that the shortness of the tail is due to the diminished length of the bones. The pelvis consists of two pairs of cartilaginous plates. There is a dermal skeleton on this fish, formed of star-shaped ossifications, each having three or four radiating branches, by which they are joined to the adjacent bones. *Solenostoma cyanopterum*, which ranges from Zanzibar to China, varies in colour, being sometimes brown, with minute spots of black and white, and sometimes pink, with small brown spots. The other species are from Amboyna.

FAMILY II.—SYNGNATHIDÆ.

The Syngnathidæ are all marine, though many species enter fresh waters. They are widely distributed over the world, but limited to the temperate and tropical regions. The openings for the gills are very small, and placed at the upper angle of the hinder margin of the gill-cover. There is only one dorsal fin, and that is soft; there are never any ventral fins, and in some examples the other fins disappear. There are two divisions of this family represented by the Pipe-fish and the Sea-horse. Of Pipe-fishes there are ten genera, and of Sea-horses five. Notwithstanding the marvellous appearances which the Sea-horses assume from the circumstance that the tail is prehensile and without trace of a caudal fin, and serves the purpose of a hand as efficiently as the tail of a monkey, the Pipe-fishes perhaps present circumstances in their history of still greater interest. The whole of the male Pipe-fishes perform the office of hatching the young in pouches on their own bodies, though in two genera named Nerophis and Protocampus the pouches are wanting, and the eggs are attached to the loose skin of the abdomen in the male. These two genera want the pectoral fin, and the caudal fin is sometimes absent, and sometimes represented by a rudiment. Some of the genera have the egg pouch for the male, which is usually closed after the eggs are received into it situate upon the abdomen, while in other genera it is situated upon the tail.

The Broad-nosed Pipe-fish (*Siphonostoma typhle*) is found on our own shores and all round the coasts of Europe, ranging into the Mediterranean and Black Sea, and as far north as Sweden. Its prevailing colour is olive-green, mottled with pale and dark shades of yellow. The usual length is a foot to fifteen inches, though Yarrell speaks of specimens eighteen inches long, and quotes Bloch as attributing a length of two or three feet. They have been taken in shallow water, where the bottom is covered with weeds. The humeral bones in this genus are movable, and are never united together to form a bony ring, as in the other Pipe-fishes. The trunk is sheathed in a series of eighteen bony rings, and the series is prolonged by about thirty-five smaller rings which cover the tail. The tail is four-sided, and terminates in a pointed caudal fin, which has the shape of a partly-opened fan. The genus Syngnathus is represented by forty-four species, many of which belong to the Malay Archipelago and Eastern Seas, several are African, a few American, and two or three are found in the Mediterranean. On our own shores the Great Pipe-fish, or Needle-fish, Sea-adder, or Tangle-fish (*Syngnathus acus*), is met with chiefly in bays and harbours. They are usually seen together in pairs, and feed on stony ground or among overhanging weeds. Sometimes small Shrimps are swallowed by them, for though the mouth is small it admits of being considerably enlarged by the action of muscles on the bones. The nostrils are close in front of the large eyes. The body is considerably lengthened, and tapers behind the dorsal fin in the female, and behind the marsupial pouch in the male. Behind the dorsal fin the body is square; in front it has seven ridges, three on each side, and a median ridge in the middle of the back. It is covered with a series of bony plates, of which there are twenty in front of the vent, and forty-four on the tail. The colour is a rich yellowish-brown, often mottled. In the young the snout is short, and the body has many fewer osseous rings; there are also fewer dorsal rays, and the lateral line is more frequently continuous with the upper edge of the tail; but when the fish gets to be more than eight inches long the characters of the adult become developed. The young fishes possess the power of reproduction; the ovaries of the female are always found well developed, and the pouches of the males, which are said by Dr. Günther to be nearly as long as the part of the body in front of the vent, are filled with eggs when they are mature. The pouch is not very deep; before the eggs are impregnated its entrance is sealed up; after the eggs have been received into it, which is a process extending over some little time, it is again sealed up by a glutinous secretion, similar to that by which the ova are held to its walls. Eggs have been found in the pouch as early as the beginning of winter; but some of the young in it are found fully developed, while others were just showing the rudiments of the snout and the eye. Couch records that in April he found the ova in the pouch all closely fastened together and attached to its walls at the sides and back, so that each egg was contained in a cell. The eggs were formed of transparent fluid, with a red spot on one side; this spot is always directed towards the opening of the pouch. Even when fully developed there is a kind of attachment between the parent and the young, and after they have escaped into the water they seek the shelter of the pouch when alarmed. The roe has been found developed in examples only four inches long.

The *Syngnathus algeriensis* is a fresh-water species from Algiers. The *Syngnathus specifer* was obtained by the Livingstone Expedition from the Rovuma River, and the *Syngnathus martensii* is found in fresh water in Borneo. The genus Ichthyocampus is characteristic of the Indian and China Seas, the genus Nannocampus is from Australia, and the genus Urocampus from Manchuria. Doryichthys is a genus with twenty species from tropical seas, some of which are taken in fresh water, like the *Doryichthys mento* from Celebes, and the *Doryichthys caudatus* from the island of Samar. *Doryichthys pleurostictus* is from the fresh waters in the island of Luzon in the Philippines. Cœlonotus is a genus from the Indian Ocean, with one species entering fresh waters. Stigmatophora is from the Australian Seas. Nerophis is eminently a European genus, though one of its seven species is from Bombay, and another from Bogotá. *Nerophis teres* is from the Crimea, but *Nerophis umbriciformis, Nerophis ophidion,* and *Nerophis æquoreus* are all British forms, ranging to the northern seas of Europe, though the last-named is also recorded from New Orleans. Nerophis has a smooth rounded body, with scarcely any traces of the ridges so characteristic of Pipe-fishes, and, as already remarked, the pectoral fin is absent, the caudal fin a mere rudiment, while the tail tapers to a point, and there are no lateral folds on the abdomen to protect the eggs, which are nevertheless carried by the male; and the anal fin is wanting.

The Ocean Pipe-fish (*Nerophis æquoreus*) is often seen by fishermen from thirty to fifty miles from land, but it has been observed to spawn in June and July in Dingle Harbour. The species clings by its tail to the tufts of *Zostera marina,* and in calm weather specimens may be seen side by side, and in this position the eggs are transferred from the female to the male. Couch mentions a female thrown on shore in a storm, which measured twenty-two inches long and an inch in depth, and a male twenty-six inches long. The upper part of the sides and tail are of a light reddish-brown, and the head and belly golden yellow. A specimen kept in the vivarium of the Scarborough Museum passed most of its time on a branch of *Lawrencia pennatifidia.* When dead it was found with its head uppermost, in the same position as in life. Couch says that this species often abounds in incalculable numbers in the open sea, and that the stomachs of other fishes like the Pollack are found gorged with them. The male has a hemispherical depression on the abdomen in front of the vent, and in this hollow the eggs are attached. They are not easily detached, and the skin rises round each like a cup.

The Worm Pipe-fish (*Nerophis lumbriciformis*) does not exceed a length of five inches. Professor Fries records that when first hatched this species possesses pectoral fins, and there is a fin-like membrane at the tail which extends up the abdomen to the vent, as well as along the back. All these fins, except the portion which becomes developed into a dorsal fin, are afterwards cast off like the tail from the tadpole.

The group of Pipe-fishes, popularly called Sea-horses, usually have filaments attached to various parts of the body, and have the head set on to the trunk at an angle which suggests the comparison with the horse. The body is deeper and shorter than in the typical Pipe-fishes, and is encased in a succession of shields forming rings of jointed armour round the body, which are distinctly marked. The males similarly carry the eggs. The genera Gastrotokeus and Solenognathus occur in the Australian Seas, and range north to China. The genus Acentronura is only known from Japan. Phyllopteryx, an Australian genus with three species, is one of the most wonderful of fishes in appearance; for as the name implies, it has very much the aspect of a moving plant. The body is usually compressed, and the snout is long. Dr. Günther, who has described the *Phyllopteryx eques,* gives the following account of the spines and filaments which cover it:—"There is a pair of small spines behind the middle of the upper edge of the snout, a pair of minute barbels at the chin, and a pair of long appendages in the middle of the lower part of the head. The forehead bears a broad, erect, somewhat four-sided crest, behind which there is a single shorter spine. A horizontal spine extends above each orbit. There is a cluster of spines on the occiput, and from these narrow appendages are prolonged. On the nape of the neck is a long spine, dilated at the base into a crest, and carrying a long forked appendage. The back is arched, and on the under side are two deep indentations. The spines on the ridges of the shields are the strongest; they are compressed, are not flexible, and each terminates in a pair of short points. There is one pair of these spines in the middle of the back, and one on each of the three prominences of the abdominal outline; they terminate in flaps, which are long and forked. There are also very

long compressed flexible spines without appendages, which extend in pairs along the uppermost part of the back, while a single series extends along the middle line of the belly. Small short conical spines run in a single series along the middle line of the sides, and along the lateral edges of the belly; and there is a pair of similar spines in front of the base of the pectoral fin. The tail, which is about as long as the body, carries the dorsal fin; it is quadrangular, and has sharp edges. It carries along its upper side five pairs of band-bearing spines, which terminate in branching filaments."

Hippocampus is a genus found in the open seas in all temperate and tropical regions. The fishes attach themselves by the prehensile tail to seaweed, or any floating substance, and thus become drifted by currents over great distances. There are eighteen species admitted by Dr. Günther,

THE PHYLLOPTERYX. *(From the "Proceedings of the Zoological Society.")*

but he remarks that the length of the snout, the shape of the shields, and the development of the tubercles, show such an amount of variation as to make great difficulties in determining the species. The body is compressed from side to side, and formed of ten or twelve rings, behind which is the four-sided tail. The shields are armed with spines or tubercles, and at the back of the head there is a prominent crest, which terminates in an elevated knob, or coronet. There are also eminences above the eyes, in the temporal region, and at the base of the pectoral fins. The males carry the eggs in a sac at the base of the tail, opening near the vent. The females have a small anal fin.

The British Sea-horse (*Hippocampus antiquorum*), which is rare on our coasts, is much more abundant in the Mediterranean, and has been found on the west coast of Africa, and the northern shores of Australia. It has often been kept in confinement. When swimming, the position is vertical, with the head more or less bent, though the angle is then rarely so great as in dried specimens. When several are together they frequently twist their tails into a band, and thus attach themselves the more firmly. This species is of a dark olive-brown colour, with bluish-white spots,

and lines on the sides and tail. The eyes move independently. On the coast of Ireland specimens have been taken from the stomach of the Cod.

Some of the species vary considerably in colour; thus, *Hippocampus guttulatus*—a species with seventeen rays in the dorsal fin—is sometimes black, with brown cross-bands; other specimens are light or dark-brown. Sometimes brown specimens have a black head and a black tail, or the body may be marbled with a dark tint, and dotted over with black spots and smaller spots of white. Most of the species are from the Australian, Malayan, China, and Indian Seas, and vary in length from two to about six inches, though the *Hippocampus longirostris*, from the China Seas, reaches a length of eleven inches. These fishes may be termed the marsupials of the sea, and Yarrell compares the pouch in which the eggs are borne to the fold of skin in which the Wandering Penguin carries its solitary egg in safety over the great wastes of waters.

ORDER III.—ANACANTHINI, OR SOFT-FINNED FISHES.

Dr. Günther divides the fishes which have no spiny rays in the vertical and ventral fins, and which have the ventral fins, when present, placed under the throat, into two principal groups, which are typified by the Cod and the Sole. This order of fishes has been named Anacanthini. When the air-bladder exists it never communicates by a pneumatic duct with the fore part of the throat. The Cod-like division is subdivided into six families, according to the position and degrees of development of the fins.

FAMILY I.—GADOPSIDÆ.

This family is known only from a single genus (Gadopsis), which is found in the fresh waters of South Australia and Tasmania, and has the fins formed partly of spines.

FAMILY II.—LYCODIDÆ.

This family includes but three genera, and one of these (Gymnelis) is met with on our own Southern coasts. It is commonly known as the Beardless Ophidium, and is the *Gymnelis imberbis*. In this genus the body is generally naked and elongated; there is no air-bladder; there are six branchiostegal rays; the vertical fins are united so as to extend down the back, and there are no ventral fins. The British species is rare, and attains a length of about three inches, and a depth of about a quarter of an inch.

FAMILY III.—GADIDÆ, THE COD FAMILY.

The Cod family includes twenty-one genera, in all of which the somewhat elongated body is covered with small smooth scales. One, two, or three dorsal fins occupy the whole length of the back, and there are one or two anal fins between the vent and the tail. The caudal fin, or tail, is separated from both the dorsal and anal fins; the ventral fins are placed on the under side of the throat. These fishes all inhabit the Arctic and temperate seas.

THE COD (*Gadus morrhua*).

The Cod is everywhere a voracious fish, taking almost any bait that may be offered, but feeding chiefly on crustacea, shell-fish, worms, and small fishes of various kinds. The natural feeding-grounds are elevated plains, or hills on the sea-bed, where they find their food on the bottom, guided by the sensitive barbel, which hangs from the under lip. As an instance of their voracity, it may be mentioned that Mr. Couch took thirty-five crabs—none smaller than half-a-crown—from the stomach of one Cod, and he records eighteen different species of crabs, and twelve long-tailed crustaceans allied to the lobster, as having been found at different times in the stomachs of Codfish in the English Channel. Their digestion is rapid, and the brittle crust of the crab is soon so far dissolved by the gastric juice as to become flexible. The Sea-Mouse, various bivalve shells, and stones encrusted with Lepralia and other Polyzoa, all contribute to satisfy the hunger of the Cod, though it can only be presumed that after the Polyzoa have been dissolved the stones are ejected from the stomach. The records of the fish upon which they feed are not numerous, but in one case six Picked Dog-fishes, each nine inches long, were found in the stomach of a Cod.

The fish are most prevalent at a depth of from twenty to fifty fathoms, and extend throughout the North European Seas, from Iceland as far south as Gibraltar, but the species does not enter the Mediterranean. A peculiar variety is found on the coast of Greenland. The species extends along the North American coast southward as far as New York. The Cod is in the best condition

for table while the roe is ripening. The eggs are shed in December and January, and after spawning the fish loses its flavour for some time. This species is one of the most prolific of fishes; the roe is often heavier than the entire weight of the remainder of the fish; but in an individual weighing thirty pounds, with a roe of only four pounds and a quarter, it has been calculated that there were as many as 7,000,000 eggs. In some cases the number may be 9,000,000. By the end of May the young are nearly an inch long, but they are never fit for market till the second year. The largest Cod caught on the Newfoundland banks occasionally reach a hundredweight, but the heaviest met with on British shores, caught between the Scilly Isles and Cornwall, have not weighed more than fifty-six pounds.

Yarrell mentions that in some parts of Scotland, as in Orkney, Fife, and Galloway, Cod have been kept in salt-water ponds which communicate with the sea by natural fissures. Here they become quite tame, and greet with open mouths the keeper who brings them boiled whelks and limpets. One is mentioned as having lived at Logan, in Galloway, for fifteen years. The Cod thrives well in confinement, and in one case, where they were retained in a pond separated from the Firth of Forth, they fed readily on sprats, young herrings, and other small fish, and devoured with evident relish the intestines of sheep. The Cod fishery has been carried on in the German Ocean since the latter part of the fourteenth century. The fish has long been found on the coast of Norfolk, Lincoln, and Northumberland, and especially on the Dogger Bank. It abounds around the coast of Ireland, and particularly on the Rockall Bank. The banks of Newfoundland and adjacent coasts have been fished since the year 1500. Here one man may take upwards of five hundred fish in a day, and in a year he is reckoned to capture ten thousand, though sometimes fifteen thousand may be caught in a single voyage. The present writer has seen small Cod caught in the Thames between Woolwich and Gravesend. When Cod are of the size of Whiting they are termed Codlings and "Skinners;" when they are larger they are known to the fishmongers as "tumbling" or "Tamlin" Cod. Of late years a considerable industry has been developed in the manufacture of oil for medicinal purposes from the livers of the Cod, but after spawning, the liver yields no oil. These fish are said to be chiefly caught for this purpose on the Newfoundland Bank. The air-bladder of the Cod is remarkably thick, and is termed the "sound." When pickled or smoked it is valued as a delicacy, and is cooked by boiling. Large numbers of Cod are dried and salted, and thus become distributed to many countries where the fresh fish could not be taken. The Cod caught on the Dogger Bank usually have the nose somewhat elongated in front of the eye, and the body of a dark-brown colour, and this variety extends all round the southern coast of England; but in Scotland the fish has a round, blunt nose, and the body is of a light-yellowish ash-green colour. Both varieties have the lateral line white like the belly. All the fins are dusky, and the upper part of the body and head are generally mottled and spotted. The head is large, and the breadth of the orbit of the eye is one-sixth of its length. The depth of the body is equal to the length of the head, and the length of the head is to the length of the body, exclusive of the caudal fin, as one to two and a half. The first dorsal fin begins just behind the origin of the pectoral; the second dorsal commences over the anal aperture. The third dorsal and second anal fins begin and finish at the same points. The tail is nearly square. There are fifty vertebræ.

Long-line fishing for Cod is carried on by large smacks, which are manned by from nine to eleven men, and remain at sea till a good cargo has been caught. Many of these boats use as many as 180 lines, each forty fathoms long. Each of these lines has a number of smaller lines attached to it, at a fathom and a half apart, and on these the hooks are placed. The total length of these lines is about eight miles, and they carry 4,680 hooks. The hooks are baited with whelk. The lines are shot into the sea about sunrise, and are laid across the tides so that the short lines, which are called snoods, may be carried away from the main line. No floats of any kind are used to raise the line from the ground, but at every distance of forty fathoms a little anchor is placed to keep the line steady, and at every mile of the length, and at the two ends, a conical buoy with a flag-staff is placed. The line is thrown out at half tide, and hauled up when the tide is nearly done. The fish are taken off the hook, have the air-bladder punctured, and are then put into the well of the ship, which occupies its central part. A constant supply of fresh water from the sea comes in through holes bored below the water line, and here the Cod will live for a long time in fair weather. If they die from being knocked

about by the rolling of the ship they are at once taken out from the well and packed in ice. Frequently a smack comes in from the Dogger Bank with twenty or more score of live Cod, and with more than half as many packed in ice. A smack with a well of this kind costs about £300 more than an ordinary vessel, so that a boat of sixty-eight tons costs £1,500. More than half the hands on board a Cod smack are apprentices. The captain is paid nine per cent. on the proceeds of the voyage, the mate gets £1 2s. a week, and the men £1 a week each. The apprentices are paid from £4 to £10 a year. The food for the crew is found by the owner. The Whelks used for bait are largely caught in the Boston and Lynn deeps, and on the Kentish coast. The long line is used to catch them, but instead of baiting the hooks, about twenty shore crabs are threaded on each snood, and when the lines are hauled up they are found to be covered with Whelks. The Whelks are also captured by putting refuse fish in shallow nets, which are sunk to the bottom. Each smack takes with her for the voyage about forty wash of Whelks, the wash being a regular measure which holds twenty-one quarts and a pint of water. The Whelks are preserved alive in bags in the well till they are wanted. The shells are then broken and the animals taken out for use. The long-line fishing season is carried on on the Dogger Bank from November to March or April, and on the Cromer Knoll from November to February. A few Cod are caught a little later on the Dutch coast, but many of the smacks then go to Iceland and the Faroe Isles, where the long-line is no longer used, and the fish obtained are salted.

From July to about the end of October Cod are fished for with a hand-line, at a distance of about ten to thirty miles from the coast, for the Cod are then following the Herrings. The only difference in the fishing is in the character of the line used. The hand-line has a sinker of lead at the end, weighing six or seven pounds. Through the upper part of this a stout iron wire passes, curving downward at the ends. To each end of the wire a smaller line or snood six feet long is fastened. The hooks are twice as large as those used with the long-line, and are fixed so that the fish cannot bite them off. There are from two to six hooks on each line. The total length of the hand-line is about forty-five fathoms. Each hand in the smack works one line, and its depth from the surface depends upon the position of the fish in the sea. The fish bite best towards sunset. About half of those caught are only half grown, but there is no reason to suppose that this destruction of young fish affects the supply for the market. When the ships arrive in port the Cod are taken from the well with landing nets and put into wooden chests, which at Grimsby and Harwich are kept floating in the water. Each chest is seven feet long, four feet wide, and two feet deep. The planks of which it is made are a little way apart at the sides and bottom to allow the water to pass freely through. A chest will hold forty large Cod, or a hundred small ones, and the fish remain alive in these boxes without deteriorating for about a fortnight. They are sent by rail to London and other markets according to the demand. But before this is done the chests are hauled out of the water and opened, one man grasping a fish by the head and tail, lifts it on to the deck, another acting as executioner, holds it firmly behind the head, and hitting it on the nose with a short bludgeon kills it at once. This is found to improve the flavour, and is thought to be more humane than to allow the fishes to die from suffocation, as they would do if sent off alive.

THE HADDOCK (*Gadus æglefinus*).

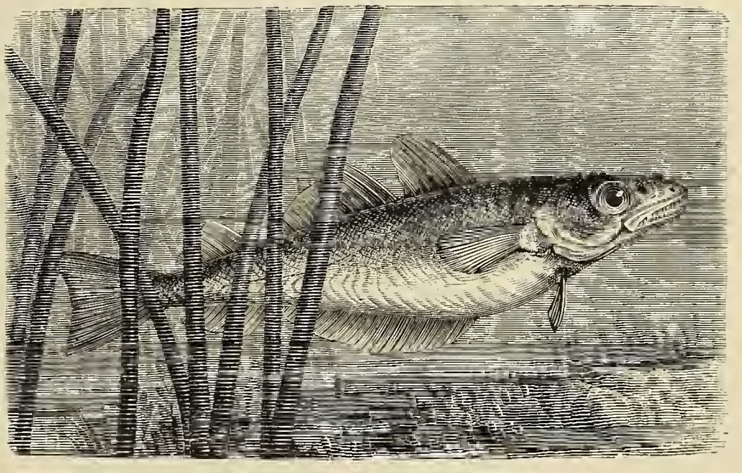
The Haddock is a migratory fish, ranging round the British coasts, the German Ocean, and the American shores of the North Atlantic. In this species the barbel is very short, and the upper jaw protrudes in front of the lower jaw. The head is relatively smaller than in the Cod. The lateral line is black; below the lateral line and between the pectoral fin and first dorsal there is a blackish blotch. Dr. Günther remarks that the skeleton may be readily distinguished from that of the Common Cod by the transverse processes of the abdominal vertebræ being much longer than the neural spines. Haddocks swim in vast shoals, and often change their feeding-ground. Their habits are very similar to those of the Cod, and the species is usually taken with the hand-line, or long-line, baited with Herring. The stomach most frequently contains univalve and bivalve shells. Edward Forbes pronounced the Haddock a "great conchologist," and Mr. Couch mentions that in a single stomach he was able to distinguish no less than twelve species of univalves and bivalves. The most frequent size of the Haddock is from two to four pounds; less frequently they attain a weight of eight or ten pounds, and occasionally a length of two feet, but on the Irish coast specimens have been recorded by Mr.

Thompson weighing as much as twenty-five pounds. They are found all round the shores of Britain, but are most abundant on the east coast. Occasionally from some unknown cause the whole surface of the sea is found covered with dead Haddocks. When kept in confinement in the salt water preserves of Scotland the Haddock becomes so tame as to take limpets from the hand. The dark patches on the shoulders are popularly attributed to the impression which St. Peter left upon it with his finger and thumb when the tribute money was taken from its mouth, the mark having been continued ever since the miracle to the whole race of Haddocks; but unfortunately for this explanation the Haddock does not exist in the sea of the country where the miracle was performed. The upper parts of the body are of a dull greyish-white, and the white belly is slightly mottled with grey.

The Whiting Pout (*Gadus luscus*), and the Power Cod (*Gadus minutus*) are species well known on the British coasts.

THE WHITING (*Gadus merlangus*).

The Whiting is met with in all the coasts of Northern Europe, and is caught in great abundance about our own shores, especially in the West of England and South of Ireland, but becomes rarer in the far North of Scotland. It is less gregarious than other species of its genus, except towards spawning time, in spring, when it assembles in schools. The species is fished for nearly all the year round, for the fish are much less exhausted by spawning than the Cod. They are taken in the largest numbers in January and February, when they approach within half a mile of shore, and seldom extend farther than three miles from land. The usual size is from twelve to sixteen inches, when the fish weighs from a pound to a pound and a half; but specimens occasionally reach the market which weigh as much as three or four pounds. Whiting prefer sandy bays, but as they feed greedily on the fry of other fishes, they often follow them for considerable distances. They are caught with the line, baited with the common mussel, or a slice of cuttle-fish. Fishing is most successful in the early morning and in the evening. Couch mentions as an example of the voracity of the fish, that four full-grown Pilchards were taken from the stomach of a Whiting that weighed four pounds. This species is especially esteemed for food for the ease with which it is digested; but as it keeps but a short time, large quantities are salted and dried. The demand for the dried fish, which are often stained yellow with an infusion of turmeric, chiefly comes from the Continent. The body of the Whiting is longer for its depth than that of the Cod. The colour on the back is a dark yellowish tinge, but the sides are paler, and the belly silver-white. There is no barbel under the jaw; the vent is below the middle of the first dorsal fin. There is a black spot at the axilla or root of the pectoral fin. The depth of the body is usually less than the length of the head. The upper jaw is longer than the lower jaw.



THE WHITING.

Among the other British species of Gadus are the *Gadus poutassou*, usually known as Couch's Whiting, which differs from the Common Whiting in its more slender shape. The Pollack (*Gadus pollachius*) has the lower jaw longer than the upper jaw. A singular instance of the pertinacity of this fish in pursuit of prey is given by Couch on the authority of Mr. Peach :—" A small Whiting was observed to have taken shelter within the cavity of a Medusa (*Cyanea aurita*), but this action was observed by a young Pollack about five inches long, which immediately began an attack. The little Whiting easily evaded the attacks by dodging round its friend, but the pursuer was soon joined

by another of its own kind. For a time both were baffled, but an unlucky movement drove the Whiting from its shelter, and a severe chase took place. Several additional Pollacks joined in the chase, like a pack of hounds, and in terror the Whiting rushed to the surface, and becoming exhausted, lay as if dead, drifting along with the tide. After a time animation returned, and the little Whiting again found refuge in the cavity of the Medusa. The movement was observed by the assembled Pollacks, which soon drove it into open water, and after a short chase it was killed by them, though they did not proceed to feed on its carcase."

The Coal-fish (*Gadus virens*) has a general resemblance to the Pollack. It is a northern fish, and especially abounds on the North American coast, and is said to range into the Mediterranean. It is met with plentifully on the coast of Cornwall, where it usually runs to a weight of twenty-five pounds, and reaches a length of about three feet. It is black on the back and dorsal fins, and lighter below. A ton and a quarter have been caught in a few hours with lines, by four men in two boats.

Species of the genus Gadus occur on the coasts of Kamschatka, California, in the Black Sea and Adriatic Sea, in the White Sea, and in the Polar regions. The allied genus, Gadiculus, which has the eye large and no teeth on the vomerine bones, is confined to the Mediterranean; and the genus Mora, which has only two dorsal fins, ranges from the Mediterranean to the Canaries. There are some other unimportant genera, like Strinsia, limited to the Mediterranean, and Halargyreus is found only at Madeira.

THE HAKE.*

The Hake frequents the coasts of Europe and North America, and ranges into the Mediterranean. It is one of the commoner British fishes, especially on the coasts of Cornwall and Devon. Unlike its allies, during the spawning season—January to April—it loses its appetite, and keeps near the bottom, and is then caught in the trawl-net. The night is the best time for fishing, and eleven hundred have been taken by one boat in two nights. When they gather together it is a sure sign that Pilchards or Herrings are approaching the coast. Several Hake are generally enclosed in the same seine net with the Pilchards; and Couch records that under these circumstances the Hake eats till it is utterly helpless, and he has seen seventeen Pilchards taken from the stomach of a Hake of ordinary size. The fish, however, is able voluntarily to discharge the contents of its stomach, and when caught with hook and line, at a great depth, the stomach is always found empty when it reaches the surface; and when caught near to the surface the contents of the stomach are disgorged when the animal is drawn into the boat. A large fish may weigh as much as twenty-two pounds, and its length varies from three to four feet. It is generally regarded as a coarse fish, but a good deal of the flavour depends upon the mode of cooking. Before being prepared for table, the mucus should first be removed with hot water containing some alkali. Large quantities are salted, dried, and exported to Spain, and it is stored up by our own fishermen for home use when stormy weather hinders them from fishing, and for the spring season, when so many fishes retire from the coasts into deep water. The head is one-third the length of the body, but the depth of the body is less than the length of the head. The ventral fins are in advance of the pectoral fins, and the pectoral fins commence just below the hinder angle of the operculum. The first dorsal fin is short, but the second dorsal commences just over the vent, and the anal fin commences just behind it. These are both long fins, which extend down the body to near the caudal fin. The head is flattened, the lower jaw long, and the inside of the mouth and of the gill-covers black. The lateral line is white, with a black border on each side. It is straight in the hinder part of the body, but curves a little upward in front, so as to terminate above the operculum. The scales are larger than in the allied fishes. The body is of a dull brown above, and lighter on the under side. When in the best condition the colour becomes of a richer tinge. Other species of Hake are met with in the Iceland seas and on the coast of Chili.

GREAT FORK BEARD.†

The Greater Fork Beard, or Forked Hake, is a somewhat rare fish in the British Seas, but ranges round the European coasts and into the Mediterranean. It grows to a length of over two feet. It has a general resemblance to the Hake, but is placed in a different genus, because there is a

* *Merluccius vulgaris.* † *Phycis blennoides.*

barbel under the chin, and the ventral fin is reduced to a single long ray which becomes forked at the end. In a specimen two feet long the longest part of the ventral ray measured eight inches, and the shortest five inches and a half. It is seen in the winter only, when it comes into shallow water to spawn. The body is of a lilac-grey colour, becoming pale on the belly; the fins are edged with black, except the ventrals, which have white tips. Other species of Phycis are found in the Mediterranean and adjacent parts of the Atlantic, and on the coasts of the United States, and at Monte Video.

The Burbot (*Lota vulgaris*) is a member of the Cod family, which is found in the fresh waters of Central and Northern Europe and the lakes of Canada, and adjacent parts of the United States. It does not occur in Scotland or Ireland, and in this country is limited to the rivers of Yorkshire, Lincolnshire, Durham, Norfolk, and Cambridgeshire, but it is far commoner in Sweden and Siberia, and other cold regions of the north. In England it rarely weighs more than two to five pounds, but heavier specimens have been taken in the Trent. Scandinavian examples are referred to weighing twenty pounds. Its habits are similar to those of the Eel, for it hides itself under stones, feeds principally during the night, and sometimes hides its body in holes in the banks. The flesh is white, firm, and well flavoured, and is preferred by some epicures to that of the Eel. The length varies from one to two feet. The chin is armed with one barbel, and the upper jaw is slightly longer than the lower; the lateral line is indistinct; the ventral fins are a little in front of the pectorals and wide apart. The body has a yellowish-brown colour, clouded with darker mottlings; the under side is white. The dorsal fins and anal fin are arranged as in the Hake. This genus may be regarded as a fresh-water representative of the Ling, to which it closely approximates in important characteristics.

THE LING.*

The Ling is essentially a northern fish, and ranges round the northern coasts of Europe to Iceland and Greenland. It is taken chiefly on the west coast of Britain, especially between the Scilly Isles and Land's End, all round Ireland, and among the Hebrides and Orkneys, but is also found on the Yorkshire coast. In the West of England the best captures are made in January and February; in the north of Ireland in March; and in the north of Scotland between May and August. It is caught like the Cod with both long line and hand line. It is not greatly valued for food when fresh, but salted is often preferred to Cod. The fish are split from head to tail, cleaned, soaked in brine, washed and dried, and taken to the ports of Spain. The Ling feeds readily on anything that comes in its way, and though preferring live fish, will take pieces of Herring, Pilchard, or Cuttle. Seven Plaice, six or seven inches long, have been taken from the stomach of one Ling, and another specimen had swallowed a Rough Hound. The air-bladders, or sounds, are said to be inferior to those of the Cod, but still are greatly valued when preserved. The roes—which sometimes reach a weight of eleven pounds—are also dried. The oil extracted from the liver was formerly burned in the cottages of the poor, and in more recent times, like that of the Cod, has been used in medicine. Couch has known Ling to weigh a hundred and twenty-four pounds. A specimen five feet and a half long weighed about seventy pounds, but the usual length is from three to four feet. The body is more elongated than that of the Hake. The lower jaw is the shorter, with a single barbel at its extremity. The teeth in the upper jaw are small and numerous, but in the lower jaw they are long, large, and form a single row. The caudal fin is rounded at its extremity, like that of the Burbot. The anal fin resembles the second dorsal; the first dorsal is somewhat elongated. The lateral line is straight; the colour of the back and sides is an olive-grey, or sometimes bluish. The belly is silvery; the dorsal and anal fins are edged with white, and behind the white tip of the caudal fin is a transverse black bar. Dr. Günther remarks that the bones of the skull are more solid than in the genus Gadus. Other species of Molva are found in the Mediterranean and on the coasts of Scandinavia.

THE MACKEREL MIDGE.†

There are two little fishes which inhabit the North Atlantic, and only occasionally visit our seas, which form the genus Couchia. In this genus there is no air-bladder; there are barbels on the upper jaw as well as on the lower jaw, and the first dorsal fin is formed of a band of short fringes concealed in a longitudinal groove. The Mackerel Midge is one of the smallest of fishes, and

* *Molva vulgaris.* † *Couchia glauca.*

occurs throughout the North Atlantic, being found in Chesapeake Bay, as well as in Scandinavia. It appears in multitudes about May in the English Channel, and in summer keeps near to the surface. It dies instantly on being taken out of the water. The length varies from an inch to an inch and a half. The colour of the back is sometimes nearly black, and sometimes bluish-green; the fins and belly are always silvery white. There are four barbels projecting from the flattened, obtuse head, and one from the under jaw. The second species (*Couchia argentata*) is commonly known as the Silvery Gade, which in Greenland reaches a length of three inches.

The Rocklings belong to the genus Motella, in which the head is no longer compressed. The small first dorsal fin consists of fringes partly concealed in a groove, much as in Couchia. There are fifteen or sixteen abdominal vertebræ, and thirty-two or thirty-three caudal vertebræ. The species occur on the coasts of Europe, Iceland, and Greenland. The Five-bearded Rockling (*Motella mustela*) has a barbel on the chin, with two barbels on the upper lip near the point of the nose, and two longer ones a little farther back. The body in its upper part is of a dark brown colour, but the sides become lighter, and the ventral fins and belly are white. The lateral line, which curves upward in its anterior part, is marked by intermittent white lines. It seldom exceeds a length of nine or ten inches, but has been found nearly twice as long. The species spawns in winter, and feeds on young fishes and thin-shelled Crustacea. The Three-bearded Rockling has barbels only on the upper lip; like the five-bearded species, it hides itself under stones, and does not take the hook. This species is sometimes thrown on shore in stormy weather entangled with seaweed. Its appearance has been compared to that of the Ling. Couch states that it is not used for food, because it acquires an unpleasant odour a few hours after being caught. Its length reaches seventeen inches. Two other species of the genus occur in the British Seas. One, the Four-bearded Rockling (*Motella cimbria*), has four barbels, one at each of the nostrils, a third on the middle of the snout, and the fourth on the chin. In this species the first ray of the anterior dorsal fin is greatly prolonged. The other species is the *Motella maculata*. One other species of the genus is known from Japan.

The Tadpole Hake (*Raniceps trifurcus*) is the only member of the genus Raniceps. It has a large broad head, and a moderately long body. There is a barb on the lower jaw. It is a wandering, solitary fish, rarely taken. Like the Rocklings, it acquires a strong odour a few hours after it has been caught. Its length seldom exceeds twelve inches. Occasionally it is brought to market with Sprats. The edge of the lip is black. The body has a darkish-brown colour, with a blue lustre, which is lost when the animal dies. Its food consists of Star-fishes, Molluscs, and Crustacea. The intestine has no pancreas. The swim-bladder is transversely divided into two parts, of which the anterior is the larger.

THE TORSK.*

The Torsk has a single dorsal fin and a narrow ventral fin, formed of five rays. The head has a single barbel; the upper jaw is the longer. The species ranges round the shores of the north of Europe and the Atlantic coast of the United States, and extends into the Polar regions. A second species, with two barbels on the chin (*Brosmius flavescens*), is taken on the banks of Newfoundland. The Torsk is sometimes seen in the Edinburgh market, being especially abundant in the Shetland Isles, and the fishermen take it on lines set for Cod and Ling. It is described as firm and tough when eaten fresh, but much better when cured and boiled. Its length varies from eighteen inches to three feet or more. It lives on rocky bottoms overgrown with seaweeds, among which it spawns. It is plentiful on the coasts of Norway, and is often thrown up dead in immense numbers on the Färoe Isles and the South of Iceland during storms.

FAMILY IV.—OPHIDIIDÆ.

This family comprises a group of fishes including sixteen genera, which are widely distributed in the ocean. There is only one dorsal fin in all these types. The ventral fin is very variable, being in some genera present and attached to the shoulder girdle, and in others replaced by a pair of barbels. Several genera have no ventral fin whatever, and in some of these the vent

* *Brosmius brosme.*

is brought forward so as to be under the throat. Dr. Günther divides the family into five groups of genera.

The first group, distinguished by possessing ventral fins, includes the genus Lucifuga, which inhabits subterranean fresh waters in Cuba. The eye is either absent or imperfectly developed, and always covered by skin. The air-bladder is remarkable for being fixed to the base of the skull. There are no appendages representing the pancreas developed at the pyloric end of the stomach. The genus Xiphogadus has the body naked. There is a pair of canine teeth developed at the corners of the mouth in both the upper and lower jaws. There is but one species, which is confined to the East Indies. One remarkable circumstance about this small group of fishes may be noticed in the fact that the genera are chiefly met with in the neighbourhood of islands, though one or two reach the Arctic regions, the Mediterranean Sea, and the San Francisco coast.

The second group, termed Ophidiina, is represented in our own seas by *Ophidium barbatum*, which, though almost confined to the Mediterranean, occasionally comes to the British coast. It is plentiful in the Adriatic, and reaches a length of nine inches. Its flavour is coarse. The ventral fins are here reduced to bifid filaments, which are placed under the lower jaw in the position of barbels. There are two small bones directed downward from the first vertebra, which are connected with a large crescent-shaped bone, placed between the processes of the fourth vertebra, and this bone fits into the anterior end of the air-bladder. The air-bladder varies in its characters in the other species of the genus. In one from Brazil the anterior bone is replaced by cartilage; but it is usually absent. The body of the Bearded Ophidium is flesh-coloured, but the edges of the long narrow dorsal and anal fins, which meet posteriorly, are margined with black.

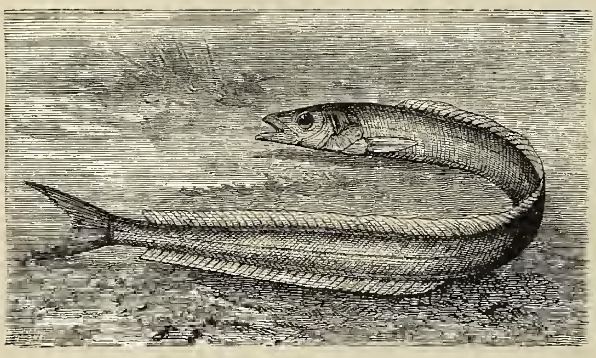
The third group, called Fierasferina, includes only two genera, both characterised by entire absence of the ventral fins, and by having the vent under the throat. The genus Fierasfer has the body naked, relatively long, with a tapering tail. The dorsal and anal fins extend throughout its length, and there is no separate caudal fin, for the tail tapers to a point. There are four gills. An air-bladder exists in all the species, but there are no pancreatic appendages to the intestine. Nine species are described by Dr. Günther; they are mostly found in the Malay seas, as at Ceram, Banda, Amboyna, Fiji Islands, and New Ireland. The species are mostly small. The *Fierasfer dentatus*, met with on the coast of Ireland and Scotland, which reaches a length of nearly a foot, is about the largest. It is a rare fish, and is chiefly known from the observations made on a few stray specimens. The head is small, about one-ninth of the length of the body. At each corner of both upper and lower jaws a large tooth occurs, which somewhat suggests the idea of a serpent's fang. The nostrils are very large, transverse, oval apertures, just in front of the centre of the eye. The operculum is strongly radiated. In a specimen eleven inches long the vent was one inch and three-tenths behind the extremity of the lower jaw, that is to say, immediately behind the head. There are in this species eighty-eight vertebræ. These fishes prefer sandy ground, on which they lie still for a large part of the day with the body in a curved position. Sir John Richardson describes, from Tasmania and the Australian seas, a species (*Fierasfer homei*) which has ninety-nine vertebræ, and the head relatively a little longer than in the British species. This species has the remarkable habit of penetrating into the respiratory cavities of the Holothurians, commonly called Sea Cucumbers, and it similarly finds its way into the bodies of Star-fishes, but the nature of this strange relationship between animals so unlike in their habits is at present unknown, and though the fish is probably seeking food, the instinct is so remarkable that the history of its development is looked forward to with interest. The second genus, Encheliophis, is distinguished by having the pectoral fins as well as the ventral fins entirely absent. The air-bladder here possesses a muscular apparatus by which its anterior part may be dilated. The species, four inches long, is found in the Philippine Islands.

The fourth group of Ophidioid fishes, named from its typical genus Ammodytina, also wants the ventral fins, but has the vent distant from the head, and consequently the anal fin is absent from the anterior part of the body. These fishes, in our own seas, are known as Sand Eels and Launces. There are only two genera, Ammodytes, which is met with on the temperate coasts of the Atlantic, in the Mediterranean, and the shores of California, and the genus Bleekeria, which is only known from Madras. *Ammodytes lanceolatus* is the species commonly known on our coasts as the Sand Eel, or

Greater Sand Eel. It sometimes reaches a length of sixteen inches, but is rarely more than a foot long. It is found around the coasts of Ireland, Scotland, and the English Channel, and on most of the shores of the North Sea. The jaws of this species have a remarkable power of expansion, so that prey can be swallowed of relatively large size. The animal swims rapidly, and is often taken in the net with Sardines and Anchovies. On the north coast of Cornwall the Launce fishery lasts from May to September. The fish are chiefly used as bait, but sometimes sold for the table. They are taken in a net about twenty fathoms long, which in the middle has a sort of bag, called a bunt, formed of fine canvas. A rope attached to one end of the net is left in charge of a man on shore. The boat is then taken out so as to spread the net in a circle and enclose the fish, when the net is drawn up into the boat. A good haul may amount to a couple of bushels, but sometimes three bushels may be taken in a single cast of the net, and it is rare for any other species to be taken with it.

The skin in this species is marked with one hundred and seventy distinct oblique folds, which are parallel to each other, and extend downward and backward, but there are no scales. The head is one-fifth the total length. The pre-maxillary bones are not capable of being protracted. There is a cartilage at the side of the lower jaw, which, according to Couch, assists the animal to pierce its way into the sand. The palate is without teeth. The back is of a bluish tinge, but the under side and dorsal and anal fins are silvery white.

The Lesser Sand Eel (*Ammodytes tobianus*) has the pre-maxillary bones protractile, and the skin of the side of the body is marked with a hundred and twenty to a hundred and thirty transverse folds. When frightened these little fishes plunge into the soft sand of the sea-bed, working their way by means of the pointed process in which the under jaw terminates. The eggs are deposited in the galleries in which it moves as it burrows beneath the sea. Like the larger species, this is also pursued chiefly for bait. It is preyed upon by Mackerel.



THE LESSER SAND EEL.

The fifth group of Ophidioid fishes includes two genera, neither of which have ventral fins. The vent is far from the head in the genus Congrogadus. The dorsal and anal fins are continuous. In the genus Haliophis the caudal fin is free. The latter genus is found only in the Red Sea, and the former ranges from Singapore to the Australian coasts.

FAMILY V.—MACRURIDÆ.

This is an important family, and includes but three genera. The body terminates in a compressed tapering tail covered with scales, which are spiny, keeled, or striated. There is one short anterior dorsal fin, and a second long one continued to the end of the tail. There are always many pyloric appendages and an air-bladder. None of the species reach our own seas. Macrurus is chiefly characteristic of the Mediterranean, but ranges northward to Greenland, and south to the Canaries, while one species is known from Japan.

FAMILY VI.—ATELEOPODIDÆ.

This family is characterised by having the long, compressed, tapering tail naked. There is only one short anterior dorsal fin, but the anal fin is very long and continuous with the caudal. The ventral fins are reduced to filaments, which are attached to the shoulder girdle. The family contains only one genus represented by a single species. Ateleopus has the maxillary bones protractile in a downward direction. The ventral fin internally is formed of two rays united together. The skin is naked. The species, which is marine, is known from Japan.

The first sub-order of Anacanthini consisted, as we have seen, of the Cod-like division, the second sub-order consists of the Sole-like division, the Pleuronectoidei.

FAMILY I.—PLEURONECTIDÆ.

The fishes of this family are popularly termed flat fish. The body is always compressed and flat, the side which rests upon the sea-bed is usually white, but sometimes marked with spots, while the upper side is coloured usually some dull brownish tint, which more or less mimics the colour of the sea-bed on which these fishes live. The eyes, which in the embryo were originally on opposite sides of the head, come both to be placed on the upper or coloured side by the migration of one eye across the head during the development of the animal, so that the bones of the head are remarkably unsymmetrical. Almost without exception the dorsal and anal fins extend the whole length of the body, which is always broad and moderately thick. There is never any air-bladder in these fishes, which are carnivorous and naturally marine, though some of them ascend rivers. Dr. Günther describes thirty-four genera. The abdominal region of the body is remarkably small, but the roe usually extends backward between the muscles towards the tail. The vent is placed well forward, being often near the throat, and frequently between the ventral fins. In the skeleton the processes of the vertebræ in these fishes are remarkably long, but are not often much developed laterally. In swimming, all these fishes retain the horizontal position. The chief British members of the family are the Holibut, Dab, Turbot, Brill, the Carter, the Topknot, Plaice, Flounder, and Sole.

THE HOLIBUT.*

This is the largest of the flat-fish family. It is rare for a specimen more than five feet long to reach the London market, but one caught near the Isle of Man, and sent to Edinburgh, weighed three hundred and twenty pounds, and measured seven feet six inches long by three feet six inches broad, but they range to a far larger size on the shores of Iceland, Greenland, and the banks of Newfoundland, and specimens have occasionally been captured which have reached a length of twenty feet. On the coasts of Norway the fishery is carried on in spring when the nights are clear, so that the fish can be seen on the bottom. Couch states that in some localities the fishermen endeavour to transfix them with a spear, but from the powerful struggles of the fish there is always some danger of the boat being overturned. When pierced it is brought to the surface very slowly, and if possible killed with blows from a club. The species is gregarious, and occurs in the greatest numbers on the Newfoundland coast. It feeds on the smaller flat fish, and many kinds of crabs. The roe is of a pale red colour, and the eggs are deposited in spring. The body is elongated, the mouth wide, and the eyes are on the right side. The teeth in the upper jaw are in a double series, but are wanting in the palatine and vomerine bones. The scales are very small. The lateral line is curved, and the hinder rays of the dorsal and anal fins are double.

A second species, found in the Greenland seas, has the lateral line straight.

The Rough Dab, or Sand-sucker, belongs to a nearly allied genus, and is named *Hippoglossoides limandoides*. It has the lateral line straight, and the small scales have ciliated margins. The conical teeth are in a single series. The species extends along the English Channel and the shores of the north of Europe. It is a broader fish than the Holibut, with a less powerful tail; it is rare on our coasts. The largest specimens seen have a length of fifteen inches. One example caught on the Cornish coast had the stomach filled with the shells of Turritella terebra, the greater number of which contained small hermit-crabs. The upper pectoral fin has ten or eleven rays which are never branched. The colour of the upper surface is yellowish-brown, sometimes varied with spots.

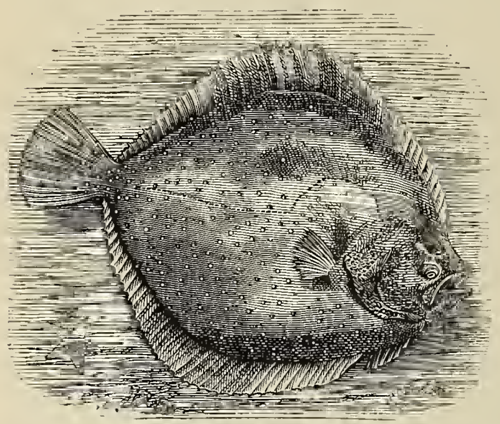
A second species occurs on the Atlantic coasts of the United States.

THE TURBOT.†

The Turbot is a broad fish, one and three-fifths as long as wide; it has no scales properly so called, but scattered over the surface are numerous flattened conical tubercles on the upper side. The lower eye is a little in front of the upper eye, the lateral line makes a semicircular curve above the pectoral fin. The longest rays of the dorsal fin are behind its middle, the colour varies from greyish to brownish, and the surface is sometimes covered with dark spots. The Turbot is the most valued of

* *Hippoglossus vulgaris.* † *Rhombus maximus.*

all the flat fish, and happily is still found in great abundance. On the north-east coast of England there is a large Turbot fishery. The fishing commences in May, and on the continental coast is largely engaged in by the Dutch. The fish migrate eastward to the mouth of the Elbe, where they are caught until the middle of August. In shallow water, and at the beginning of the season, they are taken with the trawl net, but later, when they have retired with other flat fish into deep water, they are fished for with the long line, the hooks being baited with smelt or a fish called the Gorebill. A large proportion of the Turbot supplied to the London market is caught by Dutch fishermen, and most of the Lobsters served with them in sauce are brought by Danes from the rocky coast of Norway. Good Turbot banks exist in the English Channel to the west of Dover, and along the Devonshire coast Turbot are taken by trawling. The number of Turbot brought to Billingsgate in a year is probably not far short of a hundred thousand. The Turbot is a migratory fish, travelling in companies where the bottom is sandy. It feeds chiefly on small fish, crabs, and shells, but the bait used is always some small fish of bright colour and tenacious of life, because, though voracious, the Turbot never touch bait unless it is perfectly fresh. Occasionally both sides of the Turbot are of a dark colour, and though the eyes are usually on the right side, they are sometimes found on the left side of the body. It is recorded that on one occasion the Roman Senate was convoked to advise the Emperor Domitian as to the sort of vessel in which a monster Turbot that had been brought to him might be cooked.



THE TURBOT.

On the English coasts Turbot usually weigh from five to ten pounds, though large fish range from twenty to thirty pounds, and one was taken near Plymouth which weighed seventy pounds.

An allied species (*Rhombus mæoticus*) occurs in the Black Sea.

The Brill (*Rhombus lævis*) is widely distributed round the coasts of Europe. It wants the firmness and delicacy of flavour of the Turbot, but is largely consumed in the London market. Its weight seldom exceeds eight pounds. Its food and habits are very similar to those of the Turbot. It is a narrower, longer fish, and there is no elongation of the fin-rays in the middle of the body. It never possesses the bony tubercles which characterise the Turbot, but in place of them has the coloured surface covered with small distinct scales.

The Whiff, Mary Sole, or Sail Fluke (*Rhombus megastoma*) in calm weather rises to the surface of the sea, and elevates its tail out of the water like a sail, when it drifts towards the land. It burrows at once into the sand, but is usually detected by a Gull, which pounces upon it, and taking out the liver with a stroke of his beak, drags the fish to some rock, where it is eaten at leisure. The Flukes are often followed into shore by Seals. It is said to be the most delicious fish of our seas, but is very rarely obtained. Its length is about twenty-one inches, and breadth over the fins ten inches ; the weight from three to four pounds. Dr. Günther draws no distinction between the Sail Fluke and the Mary Sole, or Carter, but Couch, not without reason, regards the Mary Sole, which is common on the south coast, as a distinct species. The variety called the Carter has a length of eighteen inches, and a depth, exclusive of the fins, of six inches. The body is much less oblong than in the Fluke. Its colour is yellowish-brown. All the bones are thinner and more delicate in this species than in the Turbot or Brill. The ventral fins are free from the anal fin.

The Topknot (*Rhombus punctatus*) is a species met with along the English Channel, and extending to the coasts of the north of Europe. It is a comparatively small species, not exceeding six inches in length and four in width. The dorsal and anal fins extend under the tail without meeting there. The scales are very small, but there are spines upon them which make the coloured surface rough. The eyes are separated by a narrow ridge ; the ventral fin is continuous with the anal fin. On the body, which is brown, are round black spots—one usually placed behind the

curve which the lateral line makes above the pectoral fin. The species frequents rocky ground, and is taken in nets set for Red Mullet. It is not an abundant fish, and is said to feed upon small star-fishes and sea-shells.

Block's Topknot (*Phrynorhombus unimaculatus*) is a fish of very similar appearance, which has nearly all the rays which form the dorsal and anal fins branched. The scales are small and spiny, and the small ventral fin is separated from the anal fin. The first dorsal ray is generally prolonged into a filament as long as the head. The colour is brownish-grey, with black spots, and a red spot edged with black occurs on the middle of the tail. It ranges from the Mediterranean to the shores of Britain, and has been taken in the English Channel and other parts of the British coasts.

The Scald-fish, or Megrim, or Smooth Sole (*Arnoglossus laterna*), is the only representative in the British Seas of a genus which is chiefly confined to the Mediterranean, but has one species (*Arnoglossus aspilus*) occurring in Java and Sumatra. In this genus the dorsal fin commences on the snout, and the scales are shed. The British species also occurs in the Mediterranean. It is usually four or five inches long, and is rarely captured, as it never takes a bait. It is chiefly met with in the stomachs of Conger Eels, and other fishes which frequent deep water. The name Scald-fish is given from the circumstance that on being even lightly handled it readily sheds its scales as though it had been scalded. The colour is usually a reddish-yellow, with paler margins to the fin; the body has the shape of the Sole, with the dorsal and anal fins somewhat elongated, but with several of the first rays of the dorsal fin separated from each other into distinct threads.

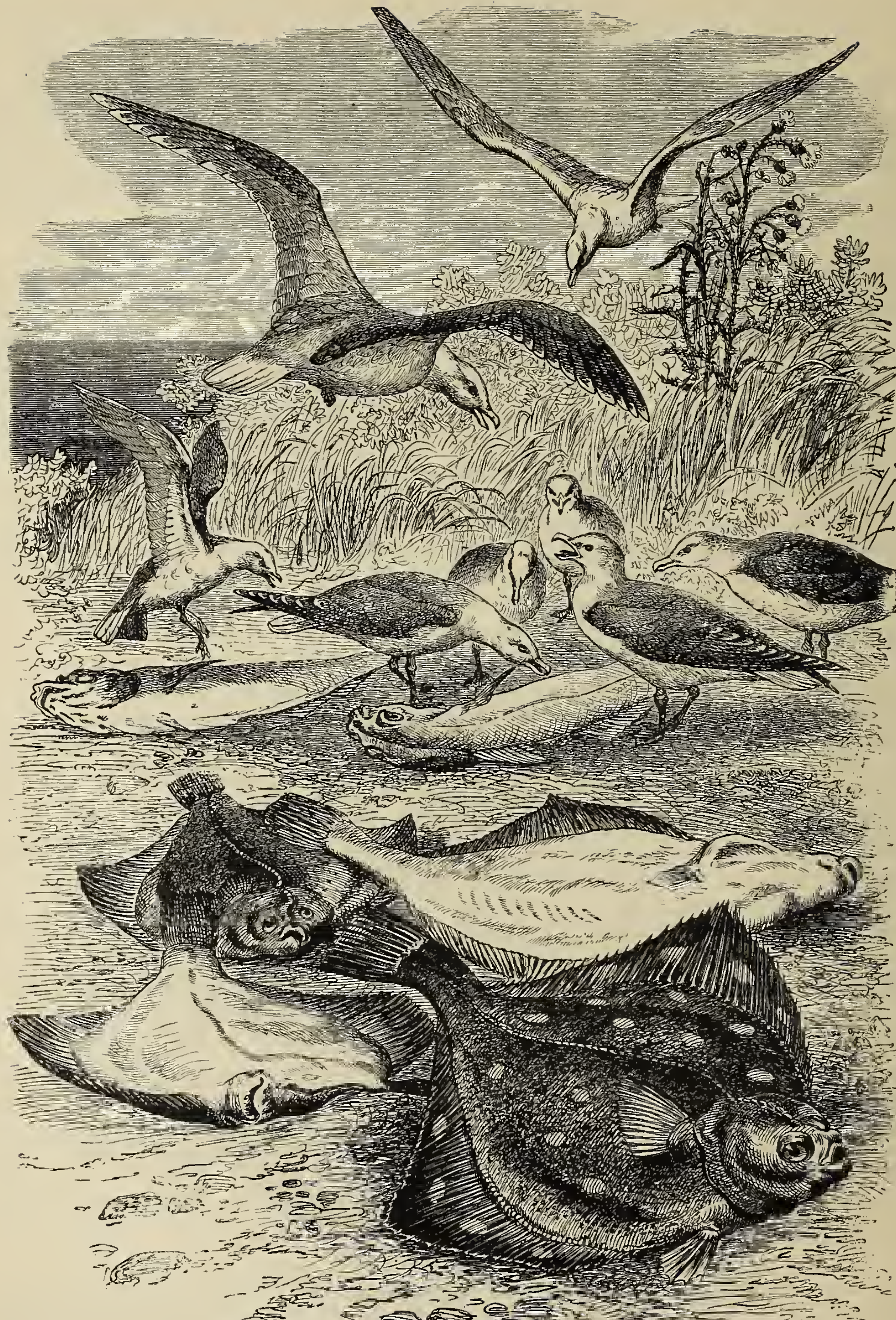
Many allied genera have a very limited distribution. Citharus is confined to the Mediterranean; Brachypleura to New Zealand; Samaris to the Chinese Seas; Psettichthys to the western coast of North America; Citharicththys is found in the tropical parts of the Atlantic and the coasts of California; Hemirhombus is another American genus, chiefly found in the West Indies and the north coast of South America. Pseudorhombus is a genus with wider range, its fourteen species being spread from Africa to Australia, China, and round the Pacific, while one species is only known from New York. Paralichthys is Californian; Rhomboidichthys is a genus with many species occurring in the tropical seas, but also represented in the Mediterranean and the Sea of Japan. The Japanese form, *Rhomboidichthys grandisquama*—which ranges to the American coast—is the only species of the genus in which the scales are deciduous.

This genus Pleuronectes, which contains the Plaice, Dabs, and Flounder, has a narrow mouth with the teeth more numerous on the lower than on the upper side of the body. They are sometimes in single, sometimes in double series. The eyes are generally on the right side. The dorsal fin always commences above the eye; the scales are always small, and in some species are entirely wanting. The species vary so much from each other that Dr. Günther well remarks that each species would have to be formed into a separate genus if the characters which distinguish them were allowed the same importance as in the other members of this family. Some forms, for instance, have the lateral line nearly straight, in others it is strongly curved. In about fifteen species the teeth are compressed, and have a lanceolate form; in the remaining seven species the teeth are conical. Some species have minute simple scales; one has the scales imbricated. In the *Pleuronectes stellatus* and *Pleuronectes asperrimus* the scales are absent, and the skin is covered with tubercles. Certain species have a prominent spine in front of the anal fin, while others want it; yet, notwithstanding these remarkable variations, the Pleuronectes form a natural group of fishes. They are unknown in tropical seas, and chiefly come from the Arctic regions and temperate waters, though represented in the Mediterranean by the *Pleuronectes italicus*, and in the Black Sea by *Pleuronectes luscus*.

THE PLAICE.*

The Plaice, though a soft and watery fish as commonly cooked, is in great demand among the poor of London, a special industry having grown up in the establishment of humble shops where it is cut in transverse slices, fried in dripping, and sold hot at the counters at a penny each piece. It forms an important item in the midday meal of workpeople in manufacturing districts; but by far the larger sale takes place in the evening, when the fat is carefully burned by the tradesman,

* *Pleuronectes platessa.*



THE PLAICE.

that its fumes may advertise his business and invite the workman to supper as he journeys home. There is a curious story told by Lacépède, which Couch quotes, concerning the common belief that Shrimps are the parents of Plaice. He states that Dr. Deslandes, having placed several Shrimps in an aquarium, found, after about twelve or thirteen days, that the vessel also contained eight or nine little Plaice. Afterwards, putting female Plaice in a vessel in which they shed their spawn, and putting in another vessel Shrimps, he obtained young Plaice only in the vessel which contained the Shrimps. He then found that grains of the roe of the Plaice were attached to the underside of these crustacea. This case is probably exceptional. It is well known that the eggs of all fishes, when shed, are contained in a glutinous covering, by which they become attached, and it would seem that the Shrimps, which feed on fish-eggs, sometimes get them adherent to their own bodies, and thus carry them about till they are hatched. Plaice have been caught weighing fifteen pounds ; a specimen has been mentioned two feet long. The general size is about three pounds, and seven or eight pounds is an unusual weight. Yarrell states that on one occasion the glut of Plaice in Billingsgate market was so great that quantities of fish averaging three pounds each were sold at a penny a dozen, and one salesman, who possessed a hundred bushels, offered them at fifty for fourpence, and afterwards for anything he could get. As it was impossible to sell them, they were divided among the poor by direction of the Lord Mayor. Fishermen can generally detect, from the appearance of the fish, the locality from which it is taken. The species inhabits sandy banks, and sometimes occurs on mud banks. On the flat sands of the Solway Firth the fishermen and their families wade into the water with bare feet ; when they tread on a fish it is held firmly till secured by the hand and placed in a basket. In the North of Europe, according to Yarrell, where the water is clear and the bottom rocky, it is captured with a heavy short spear with two barbs, to which a line is attached, which is dropped upon the fish from a boat so as to transfix it. In East Friesland the Plaice thrives well in fresh-water ponds in which it has been introduced. Plaice spawn in the early spring, and are considered to be in the best condition by the end of May. They are sometimes taken with the line and sometimes with the trawl. The height of the body is about one-half the length, exclusive of the tail ; the scales are minute and smooth ; six blunt bony tubercles extend from the eye to the origin of the lateral line. The lateral line curves a little above the pectoral fin ; the lower jaw is prominent. The upper jaw has about twenty-four narrow teeth close set on the lower side. On the upper side the teeth are few and small. The dorsal fin contains about seventy rays. There is a spine in front of the anal fin. The colour varies from brown to black with yellow spots.

THE DAB, OR SALTIE, OR SALT-WATER FLUKE.*

The Dab is met with all round the coasts of Britain, and ranges northward to Ireland, and round the northern coasts of Europe, but does not reach farther south than the coast of France. It is rarely more than a foot long, has an oval form, is met with in smooth, sandy bays, and feeds on small shell-fish, worms, and crustacea, and is in best condition in March or April. It bears carriage well, so that it is valued in the interior of France above similar fishes, and there is no doubt that its flavour is better than that of the Plaice or Flounder. It often takes the hook, but is sometimes caught in the seine net and sometimes in the trawl. The height of the body is nearly one-half its length; the small scales have the margin ciliated; there are no tubercles along the lateral line or at the base of the fins. The lateral line forms a semicircular arch above the pectoral fin, beyond which it runs straight. There are twenty-two close-set lanceolate teeth on the lower side of the lower jaw.

The Smear Dab (*Pleuronectes microcephalus*) is called by Yarrell the Lemon Dab, or Smooth Dab. It is a larger and thicker fish than the Common Dab, and is taken in the North of Scotland more abundantly than southward, and is essentially a northern fish, ranging to Iceland and the Scandinavian coast. It spawns in May and June, feeds on similar animals to the Common Dab, but is said also to feed on Chitons. It does not readily take a bait, and is usually caught in the trawl ; its flesh is said to be sweet-flavoured. Couch records specimens seventeen inches long. The scales are small, with the margins unbroken. The lateral line has a very slight curvature above the pectoral fin. There is no prominent spine in front of the anal fin. There are sometimes darker marblings on the brownish upper surface.

* *Pleuronectes limanda.*

The Pole, or Craig Fluke (*Pleuronectes cynoglossus*), is another Arctic species which frequents our own coasts occasionally, and is sometimes met with on the coast of Belgium. It has been captured somewhat plentifully with the net near Newcastle, in County Down. The stomachs contain bivalve shell-fish and crustaceans. They reach a length of sixteen or seventeen inches, a breadth of eight or nine, and a thickness of one inch. The shape is very similar to that of the Sole. The lateral line is straight, without any curve above the pectoral fin. The small scales entirely cover the head, on which they become imbricated. There is no prominent spine in front of the anal fin. The colour is greyish-brown.

THE FLOUNDER.*

The Flounder abounds on all the British coasts, and extends from France round the northern shores of Europe to Iceland and Greenland. It is common throughout the Baltic as far north as lat. 60°. Couch mentions that it is largely preyed upon by many sea birds, especially the Divers, Cormorants, and the Shag. Being unable to swallow so wide a fish, it is first pecked so as to break the bones, and then the sides are rolled together, and the fish is passed head foremost into the bird's gullet. A length of a foot is a large size; the females are probably a little larger than the males. The roe attains its full size in December, and the young appear about the beginning of the following May. The eggs are deposited at the mouths of rivers. The colour of the animal mimics that of the sea-bed on which it lives. Yarrell records that the backwaters behind Yarmouth yield dark-coloured fish, while those caught in the sands at sea have a light colour. The Flounder thrives well in the Thames, and is taken at Teddington and Sunbury. In France it occurs as far inland as the Dordogne. From Deptford to Richmond the Thames fishermen use a tuck net for its capture, One end of the net is fixed by an anchor, and its position marked by a buoy; the boat is then sculled by an apprentice in a circle while the fisherman pays out the net from the stern. When the circle is complete the net is hauled in across the fixed end. In the Avon Flounders ascend within three miles of Bath, and they live well in fresh-water ponds. Occasionally both sides are colourless, or both sides may be coloured, or the colour may vary through many shades of brown; yellowish spots sometimes occur on the sides, and, according to Blanchard, are most vivid in the spring, and disappear later in the year. The body resembles that of the Plaice in form; the teeth are obtuse and conical; the scales are minute and smooth, but there are bands of rough scales or tubercles on the side of the head; rows of rough tubercles extend along the bases of the dorsal and anal fins; the lateral line curves very slightly above the pectoral fin. In Normandy it is used, according to Blanchard, in the process of washing wool imported from America.

THE SOLE.†

There are thirty-three species of Sole, widely distributed through tropical and temperate seas; several are limited to the West Indies, others extend from the Australian coasts by way of the Malay Islands to the China Seas and Japan. A fresh-water Sole (*Solea mentalis*), seven inches long, is only known from the river Capin, in the province of Para, in Brazil. There are four British species of Sole, and one of these (*Solea minuta*) is not known from any other locality. The chief variations which species exhibit are in the presence or absence of one or both of the pectoral fins, some Japanese species wanting both fins. The constant characters are the oblong body, rounded in front; the narrow mouths, obliquely twisted to the left side, with fine teeth in bands on its blind side only. The lateral line is straight, the scales are small and ctenoid, and the dorsal fin is not blended with the tail.

The Common Sole delights in sandy and gravelly places, and abounds all round our coasts in deeper water than the Flounder or Plaice. It ranges into the Baltic and throughout the Mediterranean. Yarrell quotes Dr. M'Culloch as stating that in Guernsey a Sole had been kept in a fresh-water pond in a garden for many years, and became twice as thick as a Sole from the sea of the same size. Soles breed freely in the river Arun, near the town of Arundel, which is five miles from its mouth, remain in the river throughout the year, and bury themselves in the sand during the cold months of winter. Here they are often taken of a pound weight, sometimes weighing two pounds, and are always relatively thicker than sea Soles. Soles especially abound along the English

* *Pleuronectes flesus.* † *Solea vulgaris.*

Channel between Devonshire and Sussex. The largest specimen known was caught off Totnes, and was twenty-six inches long and eleven inches and a half wide, and weighed nine pounds.

Soles feed at night, and hence are not often taken with the line, since that kind of fishing is chiefly carried on by day. When they are caught with the line worms are used as bait. The Sole spawns in the spring; and though out of condition while depositing the eggs, recovers in a few weeks. The flesh is remarkably firm, white, and well flavoured, and the variety of ways in which it is cooked is an evidence of the esteem in which it is held as one of the best of British fishes. The height of the body is contained twice and five-sixths in the total length. The colour is dark brown.

The Lemon Sole (*Solea aurantiaca*) is distinguished by its yellowish or lemon colour, marbled with brown and speckled with black, and there is a remarkable large black spot on its hinder half. It is rather wider in proportion to its length than the Common Sole, has a smaller head, and is rather thicker; the under side of the head is nearly smooth, and the nostril there projects in a little tube. The upper jaw projects beyond the lower jaw, but its extremity is rounded. It attains a length of eight or nine inches, and is taken on the shores of Ireland and in the British Channel, but ranges southward as far as Portugal.

The Variegated Sole (*Solea variegata*) is rarely more than eight or nine inches long, and closely resembles the Common Sole. The pectoral fins, however, on both sides are extremely small. The colour is brownish-grey, with dark irregular bands extending between the dorsal and anal fins. It is thick in the body. It is plentiful at Plymouth, is met with in the stomachs of fishes caught at a depth of forty or fifty fathoms, is excellent eating, and has been taken in the Mediterranean.

The Solenette (*Solea minuta*) attains a length of five inches; it has a reddish-brown colour. The pectoral fins are rudimentary, and the lower half of the right pectoral is black. It is often found in the stomachs of larger fishes, and is taken freely with the trawl in Cornwall and Devonshire, but from its small size does not often come to market.

All these fishes, like many others which live naturally either upon or near to the ground, are captured with the trawl. This is a net in the form of a bag, which is trailed from the boat. It is usually of a triangular shape, and is so made that the mouth of the net is kept always open. The simple trawl, with the mouth distended by ropes extending from the netting to poles projecting from the sides of the vessel, is still used in the fisheries of some parts of Ireland. The favourite form of trawl is that called the beam-trawl, in which the mouth of the net is extended by a horizontal wooden beam which is raised a little above the ground by two iron supports, one placed at each side. In the large smacks the beam may be from thirty to fifty feet in length. The timber is usually elm, ash, or beech. It is considered important that the wood should have grown naturally to the proper thickness and length, though sometimes several pieces are fitted together and secured by binding. At ordinary times the beam is carried hoisted up at the side of the vessel, with one end made fast to the stern. The head irons, as they are called, carry in the top the beam, to the back of which the net is fastened. In front the rope is attached by which the trawl is hauled along, but the head irons to which it is made fast vary in shape and weight on different coasts and in different countries. The weight of the two irons as a rule varies between 230 lbs. and 360 lbs., and depends chiefly on the force of the tides in the district which is fished. These irons keep the beam nearly three feet above the ground. The net has been compared to an old-fashioned bed watch-pocket laid on its face. Care is taken to have the ground rope, which extends in front of the net round its curved outline, made of old material, so that it may break in case it should become entangled among jutting rocks or other obstacles on the bottom. The net tapers towards its hinder extremity, which is called the cod-end, and as the fish usually press upon this end when the net is full it is protected by pieces of old netting, which are named rubbing-pieces. At the entrance to the narrow part called the cod, the back and belly of the net are laced together from the outer edge inward and backward, so as to narrow the entrance through which the fish pass inward, and to form pockets at the sides in which they can swim. The entrance between the pockets is guarded by a veil of netting which hangs downward from the back of the net. This is called the flapper; fish pass under it easily, but do not readily make their way back again. The pockets are chiefly useful by taking the pressure off the sides of the net, so that the Sole, which loves quiet, naturally makes its way into the pocket, and thus, by distributing the weight over a larger space,

the pocket enables the fish to escape crushing from stones which may find their way into the trawl. The net is twice the length of the beam, but is open below for the first half of its length. The pockets are about half the length of the beam, and the cod about half the length of the pockets. The trawls are usually kept down continuously for five or six hours.

The trawl is usually towed in the same direction as the tide is running, and does not move much faster than the progress of the tide. It requires some skill and technical appliances in lowering it, so that it should reach the ground the right way up. The fish lie with their heads to the tide, close together, and when disturbed by the ground rope of the net they pass over this obstruction without difficulty into the net. When the tide is done, or the boat has reached the limits of the fishing ground, the vessel swings round with her head to the trawl, the rope is hauled in by the men at the winch, and coiled away till the beam comes to the surface. The beam is then hauled over the gunwale and made fast, and the net is got in by hand. It the catch is a good one, bringing up from half to three-quarters of a ton of fish, the winch is used to hoist up the cod on to the deck, where the fish are emptied out. Trawl fishing is much more successful at night, because the fishes feed at night, and there is more trawling in winter than in summer, because there is then more wind. In the North Sea the fishing smacks often remain for six weeks or two months with the fleet at long distances from land. Most trawling is done in a depth of from twenty to thirty fathoms. In cold weather the Soles especially pass into deeper water, and then the fishing may extend to forty fathoms or more.

CHAPTER IV.

THE ORDERS PHARYNGOGNATHI AND ACANTHOPTERYGII.

Characters of the Order PHARYNGOGNATHI—THE POMACENTRIDÆ—Distribution—Diet—Distinctive Features—THE LABRIDÆ—Characters—The Ballan Wrasse—The Cook Wrasse—The Corkwing—Other Genera—The Group Chæropina—The Group Julidina—The Rainbow Wrasse—The Genus Pseudodax—The Group Scarina—The Group Odacina—THE EMBIOTOCIDÆ—THE GERRIDÆ—THE CHROMIDES—The Order ACANTHOPTERYGII—Dr. Günther's Classification—THE PERCIDÆ—The Perch—Where Found—Diet—Large-sized Specimens—Characters—The Bass—The Ruffe—Allied Genera—The Smooth Serranus—The Dusky Perch—The Stone Bass, or Wreck-fish—Why so Called—THE PRISTIPOMATIDÆ—THE SQUAMIPINNES—Characters—Various Genera—Curious Habit of Shooting at Insects—THE NANDIDÆ—THE MULLIDÆ—THE RED MULLET—Epicurean Luxury—Mode of Cooking—THE SPARIDÆ—THE BLACK SEA BREAM, OR OLD WIFE—The Bogue—The Common Sea Bream—The Gilthead—THE HOPLOGNATHIDÆ—THE CIRRHITIDÆ—SCORPÆNINA—THE POLYCENTRIDÆ—THE TEUTHIDIDÆ—THE BERYCIDÆ—THE KURTIDÆ—THE POLYNEMIDÆ—The Maigre—Value of its Head—The *Woman-hater*—THE XIPHIIDÆ—The Common Sword-fish—Contests between Fox Sharks, Sword-fishes, and Whale—The "Sword"—THE TRICHIURIDÆ—The Scabbard-fish—The Silvery Hairtail—THE ACRONURIDÆ—THE CARANGIDÆ—The Scad, or Horse Mackerel—THE CYTTINA—The John Dory—Characters—Whately's Little Joke—Legends about the Dory—THE STROMATEINA—THE CORYPHÆNINA—The Ray's Bream—The Opah—THE NOMEINA—THE SCOMBRINA—THE MACKEREL—Young "Shiners"—Size—Abundance—Migrations—Voracity—Mackerel-fishing—The Spanish Mackerel—The Tunny—Characters—Size—The Tunny Harvest—Beef-like Flesh—The Bonito—The Germon—The Genus Pelamys—The Genus Auxis—The Pilot-fish—THE SUCKING-FISH, OR REMORA—Nature of the Sucking Disc.

ORDER IV.—PHARYNGOGNATHI, OR FISHES WITH JAWS IN THE THROAT.

THE order of fishes termed Pharyngognathi is so named from the circumstance that they have lower bones in the gullet, termed pharyngeal bones, which are blended together, though there is frequently a median suture between them. The air-bladder in these fishes is not connected with the throat by a pneumatic duct. The order is moreover distinguished by some of the rays of the dorsal, anal, and ventral fins forming spines, and showing no indication of the usual jointed structure. Dr. Günther follows Müller in his definition of the order, but divides it into five families, named from typical genera—Pomacentridæ, in which the scales are ctenoid; Labridæ, in which the scales are cycloid; Embiotocidæ, which have numerous rays in the anal fin; the Gerridæ, which have few rays in the anal fin; and the Chromides, which entirely want the pseudo-branchiæ, or gill on the operculum.

FAMILY I.—POMACENTRIDÆ.

This family includes eight genera, distinguished by having twelve vertebræ in the abdomen and fourteen in the tail. They abound chiefly in the Indian and Pacific Oceans. Some extend as far as the south coast of Australia and to the Pacific shores of America. A few reach northward to Japan, and some are found in the Mediterranean. Their food varies with the locality; in the neighbourhood of coral reefs it consists chiefly of marine plants and the various small zoophytes which there flourish, but almost all small marine animals contribute to their ordinary diet. These fishes have a compressed and somewhat short body, the lateral line on which does not extend to the caudal fin. There is one dorsal fin with the spiny part well developed. The anal fin has two or three spines, the remainder being soft like the dorsal. The ventral fins are placed in the thoracic region. The intestine, which is moderately long, has a few pyloric appendages behind the stomach. The different genera are distinguished by the form and arrangement of the teeth, and the presence or absence of serrations on the opercular bones. Many of these fishes are remarkable for the variety of their colours: thus, Amphiprion has a black or brown ground colour, with white or pearly cross-bands, while some of the fins are often of a bright yellow. In the allied genus, Dascyllus, the cross-bands, when they exist, are usually black on a yellow ground, but sometimes the body is green and the tail blue. In Glyphidodon the cross-bands are indifferently light and dark, and the colour of the body varies, and in several genera the scales often have a dot of different colour from that which pervades the back and body.

FAMILY II.—LABRIDÆ.

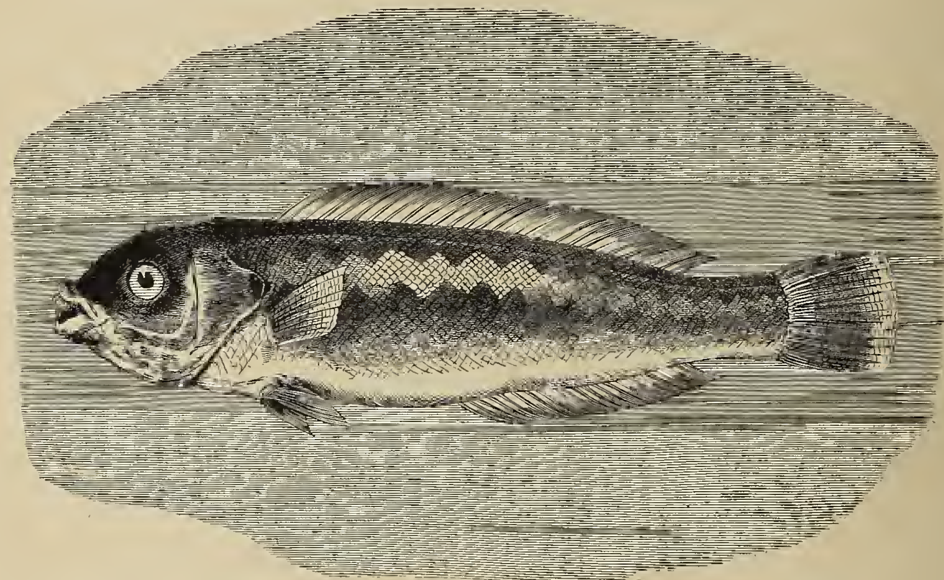
The Labroid family comprises a vast number of marine fishes, which are met with in temperate or tropical waters. They are unknown in the Arctic and Antarctic Seas. They feed chiefly on mollusca, and the dentition on the single lower pharyngeal bone is well suited for crushing shells. Many species have a strong curved tooth at the hinder end of the pre-maxillary bone, which presses a shell against the lateral and front teeth, by which it is crushed. The body is covered with cycloid scales; the lateral line does not always reach to the caudal fin. There are no pyloric appendages to the stomach. In this family Dr. Günther arranges forty-six genera, which are classed, according to the characters of the teeth, fins, and scales, into six groups. The genus Labrus is found on the coasts of the temperate parts of Europe and off the northern shores of Africa. There is a peculiarity in the skeleton in this type, in that the basi-occipital bone has on each side a large surface like a flattened condyle, which fit into concavities in the upper pharyngeal bones. The teeth in the jaws are conical, and ranged in a single series. This genus includes many of the Wrasses.

The Ballan Wrasse (*Labrus maculatus*) is perhaps the best known. It is found sheltered among seaweeds in deep holes among the rocks. It spawns in spring and summer, when the colours become most brilliant. It is said to feed chiefly on crustacea and marine worms. A large specimen may reach a length of eighteen inches, but on the Irish coasts they grow to a much larger size. The back is often red and the belly orange, while the body is ornamented with bluish-green spots. All the scales are margined with colour. The pectoral and ventral fins are orange-red, but the vertical fins are usually bluish-green. This species has a wide distribution on the European coasts, through the Mediterranean, and on the north-west of Africa. The young of the Ballan Wrasse has the pre-operculum well serrated, and has been regarded by some writers as a distinct species.

Another well-known species is the Cook Wrasse (*Labrus mixtus*). This species, which is also known by many popular names, such as the Red Wrasse, Striped Wrasse, and Spotted Wrasse, is remarkable for the great difference of appearance which distinguishes the sexes. The male has the body of a dark greenish tint above, becoming yellower on the body, and is marked with blue stripes running the length of the body. The female, on the other hand, is red, with two or three large black spots or blotches across the back of the tail. The young males are said greatly to resemble the females. Like the other species of its genus, it is found chiefly among rocks and the larger seaweeds, feeding on crustacea. During the summer these fishes come into shallow water, but in the autumn they retire again to a deeper part of the sea. The males may

reach a length of fourteen inches, but the females are rarely more than a foot long. The female in the Mediterranean is said to breed twice in the year. It is common in the North Atlantic, but more abundant on the southern shore of England than farther eastward. It does not enter the Baltic, and has not been met with in Iceland or Finnark.

The Corkwing (*Crenilabrus melops*) is a Wrasse which ranges round the coasts of Europe. There is a brown or black spot behind the eye, the sides of the head are red, the back has a purplish tinge, and the under side is greenish. The body is marked with longitudinal stripes, which have a violet colour in the upper part, but become red lower down. The dorsal, anal, and ventral fins are green, and the pectoral fins reddish-yellow. This species has a deeper body than any other British Labroid fish. The scales number thirty-seven on the lateral line, above which are four rows of scales, and there are ten rows below it. In this genus the pre-operculum is denticulated, as in the young of the



THE RAINBOW WRASSE.

genus Labrus. All the species have imbricated scales on the cheeks and on the opercular bones. The conical teeth in the jaws are arranged in a single series.

The other species are all confined to the Mediterranean, the Black Sea, and the neighbourhood of Madeira.

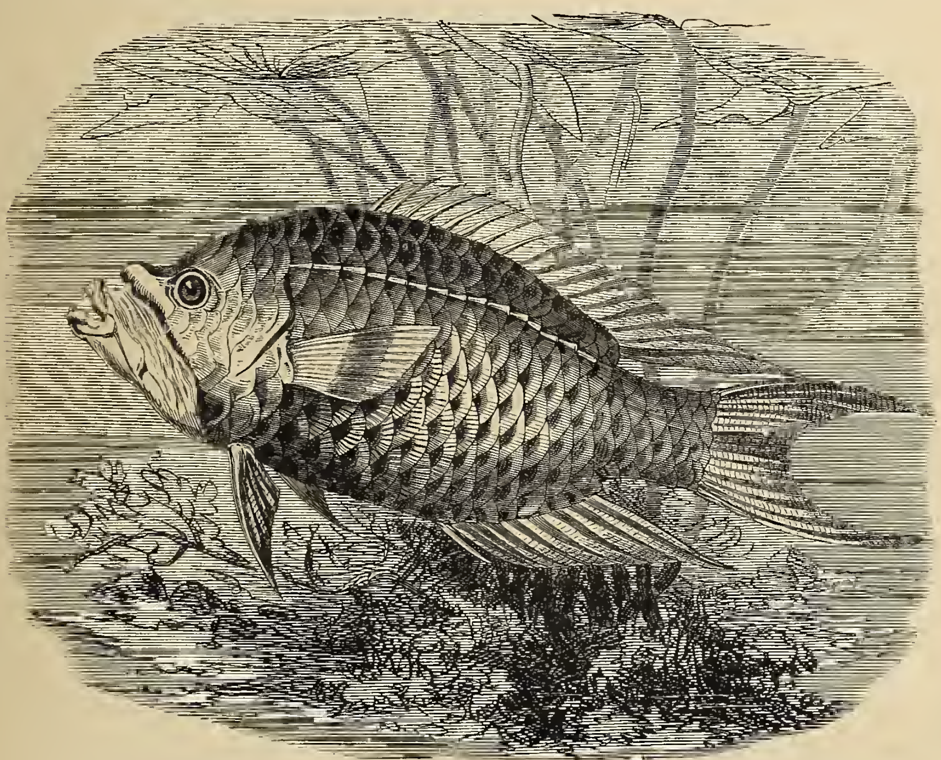
Lachnolaimus is a genus confined to the Caribbean Sea. The genus Tautoga is a black fish from the Atlantic coasts of the Northern States of North America. Malacopterus is another genus from the island of Juan Fernandez; Ctenolabrus is a genus found in the Mediterranean and temperate parts of the North Atlantic, represented in our own seas by *Ctenolabrus rupestris*. The genus Acantholabrus is represented on the coast of Cornwall by a species named in honour of Mr. Couch. Centrolabrus ranges from the Canary Isles to Greenland, is known on our own coast from one species, the *Centrolabrus exoletus*, and is distinguished by the small size of its mouth. The fish is seldom more than four inches long. There are sixteen rows of scales on each side, and thirty-two scales on the lateral line.

The second group of Labroid fishes has been named Chæropina. It includes only the one genus Chærops, which is found in the Indian and Australian Seas, and has a species ranging to China and Japan.

The third group, named Julidina, includes thirty-seven genera, distinguished by having, as a rule, fewer than thirteen spines in the dorsal fin, and frequently, in some groups of genera, only

eight or nine spines. These fishes are widely distributed in the Indian Ocean, in the Caribbean Sea, and Pacific coasts of North America, and a few range to China and Japan; but the only British representative of the group is a species of the widely-distributed genus Coris—the *Coris julis*—which has a small black spot just over the origin of the pectoral fin, a blue spot on the extremity of the operculum, and a violet spot between the three or four anterior dorsal spines. This species is commonly known as the Rainbow Wrasse. It is frequently met with in the Mediterranean and at the Canary Isles. Its most northern limit is the south coast of England. There are many varieties, distinguished by red or white lateral bands. In the genus Epibulus the lateral line is interrupted, and the cheeks and opercular bones are covered with large scales. The species here figured comes from the Indian Archipelago, and is the only member of the genus.

The fourth group includes but one genus—Pseudodax—which frequents the seas between Java



THE EPIBULUS INSIDIATOR.

and the Celebes, and is distinguished by having each jaw armed with two pairs of broad incisors with a cutting lateral edge, and the teeth on the lower pharyngeal bones are said by Dr. Günther to be confluent.

The fifth group, including five genera, is named from the type genus Scarus—Scarina. These fishes are confined to the tropical seas, and chiefly known from the labours of Dr. Bleeker. They have the teeth in both jaws blended together so as to form broad convex cutting edges. Here, also, the pharyngeal teeth form a pavement.

The sixth and last group of the Labroid family, named from the genus Odax—Odacina—includes four genera. The edge of each jaw is sharp and cutting, without the teeth being distinct in front, the scales are small, and the snout is pointed.

FAMILY III.—EMBIOTOCIDÆ.

This family includes two genera—Ditrema, which has seven to eleven dorsal spines, and is represented by many species, and Hysterocarpus, known from one species. Both genera ascend

some of the Californian rivers. These fishes are viviparous; they have a large simple air-bladder, and the stomach is destitute of pyloric appendages.

FAMILY IV.—GERRIDÆ.

The Gerridæ comprises the one genus Gerres, represented by many species in tropical seas. These fishes are oviparous; they have rudimentary pyloric appendages. There is always an air-bladder.

FAMILY V.—CHROMIDES.

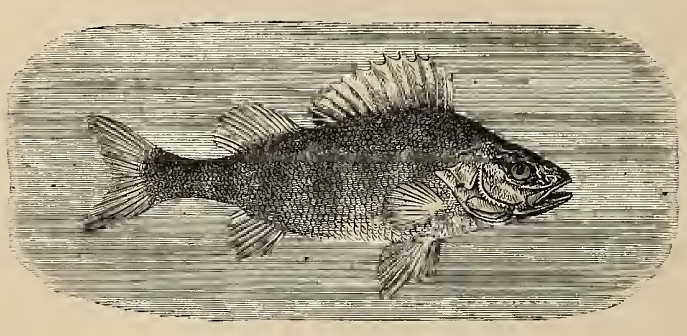
The fifth and last family is the Chromides, a large group of nineteen genera, distinguished by their teeth, spines, and scales. They are fresh-water fishes, which are chiefly met with in the tropics. One genus, Etroplus, occurs in Western India. The herbivorous species have the intestines convoluted and the teeth lobed; but there are carnivorous species, with simple pointed or conical teeth. Chromis galilæus is from the Sea of Galilee. Chromis, Sarotherodon, and Hemichromis are African genera; the others are all American.

ORDER V.—ACANTHOPTERYGII, OR SPINY-FINNED FISHES.

The Acanthopterygii comprise a vast multitude of fishes, among which are some familiar fresh-water forms which occur in the rivers of our own country. All these genera are characterised by having the inferior pharyngeal bones separated from each other, and by having some of the rays of the dorsal, anal, and ventral fins developed into spines, and therefore wanting in the jointed character which is seen in the remainder of the fin rays. The air-bladder is sometimes absent and sometimes present, but it never possesses an air-duct to connect it with the throat. In the following pages the genera are arranged according to the system developed by Dr. Günther. In his arrangement of the fishes in the British Museum, five principal subdivisions of the order are adopted; the first of which includes sixteen out of the twenty groups of families, or smaller natural divisions of the order. The first section of the order, comprising the sixteen divisions, is distinguished by having a soft dorsal fin and an anal fin. The vent is always distant from the extremity of the tail, and is placed behind the ventral fins whenever they exist. The first division of this great group, termed Perciformes, comprises eleven families, in which the dorsal fin or fins occupy the greater part of the back; and the soft anal fin is similar to the soft dorsal. The ventral fins are placed under the throat; they have one spine and four or five well-developed rays.

FAMILY I.—PERCIDÆ.

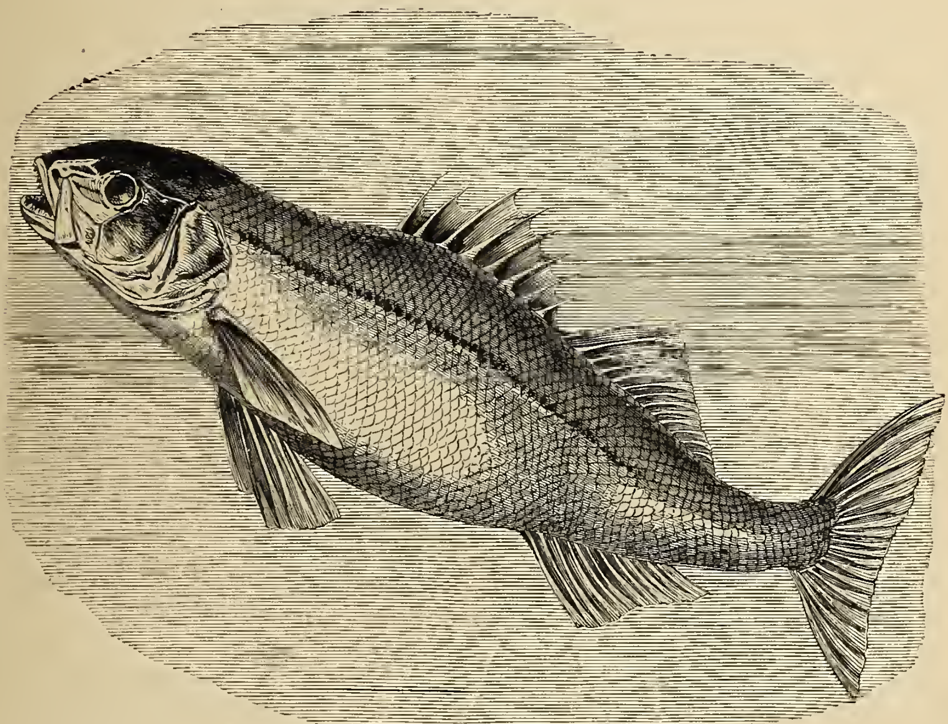
The type of the Perciform division is the Perch, best known from the *Perca fluviatilis*, which is widely distributed throughout the temperate parts of Europe and Russia in Asia, where it is confined to fresh waters. Two other species are known, both of which are found only in Canada and North America. The Perch is said to be wanting in the more northern counties of Scotland, though it inhabits Scandinavia up to the 69° parallel of latitude. These fishes feed on insects, worms, and many small fishes. The eggs are deposited in long strings during spring, and number more than a quarter of a million in a single fish. Yarrell observes that they live so well out of water that they are constantly to be seen alive in the markets of Southern Germany, from which they are taken back again, if unsold, to the ponds from which they were brought. Occasionally this species reaches a large size. One weighing nine pounds is said to have been caught in the Serpentine in Hyde Park; and Yarrell quotes Schäffer as stating that the head of a Perch, which measures nearly a foot in length, is preserved in the Church of Lulea, in Lapland. English specimens



THE RIVER PERCH.

have not measured more than twenty-nine inches in total length. In Lapland the skins of the Perch are boiled in a bladder, so as to form a kind of glue. The head is two-sevenths of the length of the body; the teeth are small, and directed backward. There are also teeth on the palatine bones. The upper part of the body is of a warm greenish-brown tint, becoming golden at the sides and white on the belly. There are always broad dark bands of colour passing vertically down the sides. In summer the Perch prefers the rapid parts of the stream, but in winter the fish retire to deeper and quieter pools, where they herd together in large numbers.

The genus Percichthys is confined to the fresh waters of tropical America and Java. Paralabrax is a genus limited to the rivers of California. Labrax has some species living in the rivers and shores of North America, but is best known from the European species called the Bass



THE BASS.

Labrax lupus, which is a marine Perch, having teeth on the tongue and only nine spines on the first dorsal fin. There are scales on the gill-covers, as was pointed out by Aristotle. The species is gregarious, and enters the mouths of rivers in autumn to deposit the spawn. The individuals feed on various small fishes, such as young Whiting and the Sand Launce, and eat Shrimps and other small Crustacea. They are more abundant on the south coasts of England and Ireland than farther north, and range to France, Portugal, and the Mediterranean.

Another fresh-water fish met with in the rivers of Europe, and closely resembling the Perch in its habits, is the *Acerina cernua*, commonly known in this country as the Ruffe, a name said to be derived from the harsh sensation given by its ctenoid scales. It is of an olive-green colour, marbled and spotted with brown. Many genera of this family are limited in their range. Percarina is found only in the Dniester, Pileoma in the lakes and rivers of North America, Niphon is a genus met with in the Japanese sea, and Enoplosus occurs in the Australian seas.

Another section of the Perch family has for its type the genus Serranus, which genus alone comprises more than 130 species. It is represented in our own seas by the *Serranus cabrilla,* or

Smooth Serranus, and the Dusky Perch (*Serranus gigas*). In this genus both jaws have very distinct canine teeth. The Dusky Perch is met with on the coasts of France and Spain, and in the Mediterranean, where it sometimes reaches a weight of sixty pounds, though in the Indian Ocean its size becomes enormous. In our own seas they vary from ten to twenty pounds. The colour of the back is a dark reddish-brown, becoming paler on the belly. The Smooth Serranus also abounds in the Mediterranean, and reaches southward to Madeira. This fish has sometimes been believed to be hermaphrodite, one lobe of the roe consisting of ova and the other lobe consisting of milt; but this view, though sanctioned by Cuvier, is probably an error, due to some peculiarities in its reproductive apparatus.

Plectropoma is a genus limited to the tropical seas of both hemispheres. In our own seas the Stone Bass (*Polyprion cernium*) is met with. The species ranges southward to Madeira and the Mediterranean. It has sometimes been called the Wreck-fish, from the circumstance that it often comes in with fragments of wreck, which are covered with the goose-barnacle. Couch remarks that they gambol round these floating objects, and he has known their tails to be excoriated by rubbing against the wreckage. They do not feed on the barnacles. As many as thirty-five have been taken by a single boat round one piece of wreck. The fish is about eighteen inches long, and is valued for table.

FAMILY II.—PRISTIPOMATIDÆ.

This is a large family, and is distinguished from the Percidæ by having the palate toothless. In one or two genera there are no teeth, but usually minute teeth are arranged in bands, and in some genera they are pointed and conical. The air-bladder is usually undivided. They are carnivorous fishes, found in the seas of temperate and tropical regions; a few occur in fresh waters. In our own seas the group has but two representatives—*Dentex vulgaris* and *Mæna vulgaris*. Dentex is a widely-distributed genus, met with in the Mediterranean, Atlantic, Red Sea, Sunda Sea, and the Sea of Japan. It always has strong canines in both jaws. There are only six branchiostegal rays; the dorsal fin is continuous. There is a notch at the posterior end of the swim-bladder. The British species is a rare visitor on our own coasts, and is more at home in the Mediterranean and about the Canary Islands. It carries four canine teeth in each of the jaws, the outer pair stronger than the inner pair. The fourth dorsal spine is the longest. The colour is silvery-blue, with some irregular black spots on the back. *Mæna vulgaris* scarcely extends beyond the Mediterranean, and in British waters has only once been met with on the Cornish coasts.

FAMILY III.—SQUAMIPINNES.

The Squamipinnes comprise twelve genera, arranged in three divisions, according to the presence or absence of teeth on the palate and the position of the dorsal fin on the back. This is a group of carnivorous fishes, especially abounding in the Indian region and other seas between the tropics, though a few genera have a wider range, and enter rivers. The intestine is generally convoluted; the stomach forms a pouch, and has a few pyloric appendages. The vertical fins are more or less covered with scales, the eyes are placed laterally, and the teeth are like short bristles. The body is compressed and remarkably deep, and frequently marked with black and white spots and transverse or oblique bands, the colours of which are extremely brilliant. Swainson observes that the Chætodons are the most beautiful of the whole class of fishes. None of them are large, and all are said to be nutritious and savoury food. Among the genera of this family, Chelmo has the muzzle elongated into a cylindrical tube, with a small cleft in front for the mouth. There are no teeth on the palate, and there is no spine on the pre-operculum. The body is greatly compressed from side to side, and is deep. *Chelmo rostratus* has five vertical brown cross-bands, which are bordered with white and brown. A round black spot bordered with white occurs in the middle of the soft part of the dorsal fin. This species sometimes ascends rivers, but is chiefly found in the Polynesian seas between India and the West Coast of Australia. Heniochus is distinguished by having the fourth spine of the dorsal fin prolonged into a delicate whip-like process. Holacanthus has a long strong spine developed from the posterior angle of the pre-operculum, and a similar spine is seen in Pomacanthus. Ephippus has the colour uniform in the adult. Atypus and Scorpis are two genera which are almost limited to the Australian seas; both these types have the dorsal fin

THE TOXOTES.

in the middle of the back. Atypus feeds on vegetable as well as animal substances. The genus Toxotes has the dorsal fin, which contains only five spines, placed on the posterior half of the back.

Many of these fishes possess the remarkable habit of shooting at insects observed upon plants which overhang the water or fly above it, by forcibly ejecting water from the mouth, a circumstance remarked upon by Swainson as being altogether unique as a hunting habit and mode of capturing prey.

FAMILY IV.—NANDIDÆ.

The Nandidæ are a small family, including about six genera of tropical fishes, which are all carnivorous. The body is compressed and oblong, and, unlike all the foregoing three families, has the lateral line interrupted. The ventral fins are placed under the thorax. The pseudo-branchiæ, which occur in the marine genera from the Red Sea and the Pacific, are absent in the fresh-water genera of the East Indies, and hidden in the genus Acharnes, which is met with in the fresh waters of British Guiana.

FAMILY V.—MULLIDÆ.

The Mullidæ are distinguished by having a pair of long movable barbels on the throat attached to the hyoid apparatus. There are four branchiostegal rays and two dorsal fins, which are distant from each other. The profile of the head is always a convex curve, and the elongated body is covered with large scales. There are five genera of these Mullets, which chiefly inhabit tropical seas, though the genus Mullus, which includes only two species, is limited to the Mediterranean and the temperate coasts of Europe. The Australian genus, Upeneichthys, makes its way up rivers. Both the Red Mullets occur on our own coasts. The *Mullus barbatus* is rare, and met with only occasionally on the coasts of Berwickshire and Cornwall, though it is abundant in the Mediterranean. Its colour is duller than that of the Red Mullet, and varies between red and olive-yellow.

THE RED MULLET.*

This fish is also called the Striped Surmullet, from the circumstance that its bright red colour is relieved by three longitudinal stripes of yellow. The flesh of this fish is white, firm, and remarkably free from fat, and has always been esteemed one of the epicure's greatest luxuries. Its flavour improves with the size, and small fish deprived of the liver are more or less insipid. The method of cooking by rolling them in paper to prevent injury to the skin has been observed for at least two thousand years. Among the Romans Mullet of moderate size were worth their weight in silver. In this country they do not usually exceed three pounds and a half in weight. Couch mentions one which was sixteen inches long. After death the colours fade. The species is migratory, but most abundant in the English Channel. They are often caught in Mackerel-nets, near to the surface, but more frequently in the trawl-net. Occasionally they are so abundant that five thousand have been taken in a single night. Their rarity at times is a consequence of their migratory habits, and the circumstance that their home is then unknown to the fishermen. The Red Mullet feeds on small crustacea and thin-shelled mollusca.

FAMILY VI.—SPARIDÆ.

The Sparidæ are a large natural family, including upwards of twenty genera, and a multitude of species, which are commonly known as the Sea Breams. These fishes have the body compressed and oblong. The scales are minutely serrated; the branchiostegal rays vary from five to seven; the bones of the head have a rudimentary system of mucus canals; the dentary organs are either of a grinding character at the sides of the jaws, or are cutting teeth placed in front of them. The air-bladder is often divided posteriorly. Dr. Günther divides these fishes, some of which are herbivorous and others carnivorous, into five groups, which are named from typical genera.

THE BLACK SEA BREAM, OR OLD WIFE.†

This is a fish of solitary habits, which frequents the west and south coasts of England and Ireland in summer and autumn, but ranges southward to the Mediterranean Sea and Canary

* *Mullus surmuletus.* † *Cantharus lineatus.*

Islands. It feeds and fattens on delicate seaweeds, but readily takes the hook when baited with Mussel. It reaches a length (exclusive of the fins) of seventeen inches and a depth of five inches and a half. It is not greatly valued for food. It is sometimes flesh-coloured on the cheeks, green on the back, and reddish-yellow on the body, but when the colours fade Couch states that it acquires a dull sooty tint; but the colour varies with the season. The fins are blackish-grey. There are ten vertebræ in the abdomen and fourteen in the tail. The other species of this genus are found in the Mediterranean, Cape Seas, and Indian Ocean.

Box vulgaris, called the Bogue, has remarkable crenulated incisor teeth. It is rare on our south coast, but ranges to the Mediterranean, Canary Isles, and Caribbean Sea. Couch's Sea Bream (*Pagrus orphus*) is another rare visitor to the Cornish coast, better known from the Canary Islands. Pagellus erythrinus is a red fish, ranging from the mouth of the Danube to the Canaries, and northward to our own shores. Pagellus Oweni is another Sea Bream, which, however, is known only from the British seas. The Common Sea Bream (*Pagellus centrodontus*) is one of the commonest of British fishes, breeding in late autumn or winter. In severe seasons it retires to great depths. At the close of summer it assembles in schools, when 20,000, or even 60,000, have been taken in the seine net. When thus abundant it has been sold for half-a-crown the hundred-weight. It feeds indifferently on small fishes, crustaceans, and seaweeds. The Gilthead (*Chrysophrys aurata*) is an allied Mediterranean fish, which occasionally reaches the coasts of Cornwall and Devon. All the Sparidæ are acutely sensible to change of temperature, which influences their place of habitation in the sea.

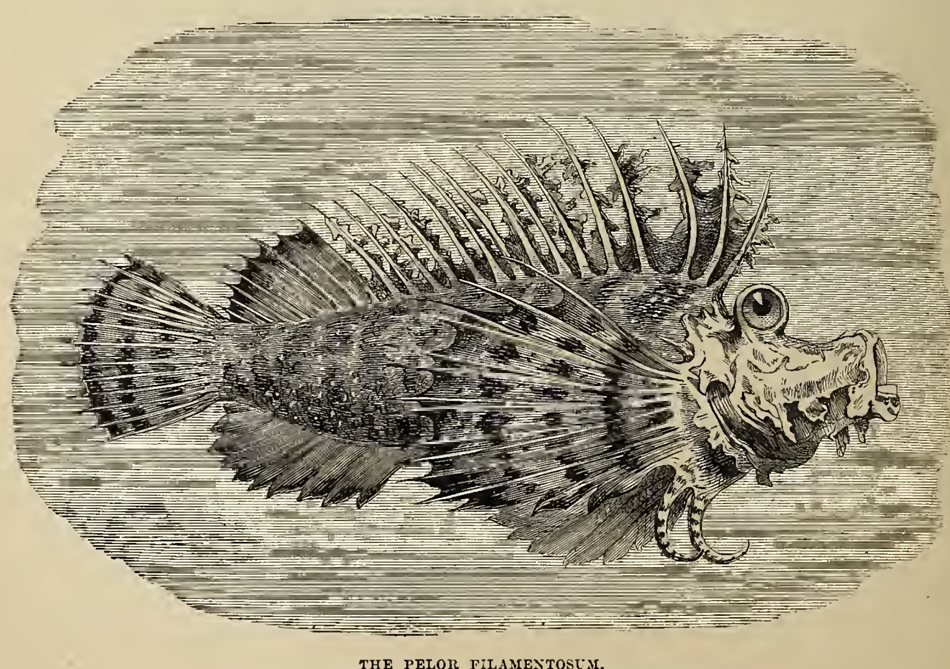
Many of the families which follow are chiefly remarkable for the minor peculiarities of structure, or geographical distribution, to which attention is briefly drawn.

FAMILY VII.—HOPLOGNATHIDÆ.

The Hoplognathidæ, which have compressed and deep bodies, have the bones of the jaws forming a sharp dentigerous edge. The three species are limited to the seas of China, Japan, and Australia.

FAMILY VIII.—CIRRHITIDÆ.

The Cirrhitidæ are a family with the body compressed and oblong. The branchiostegal rays vary from three (in the genus Nemadactylus) to as many as six. The lower rays of the pectoral fin are not



THE PELOR FILAMENTOSUM.

branched. The family includes eight genera, which are confined to the tropics, though some species range farther south.

FAMILY IX.—SCORPÆNINÆ.

The Scorpæninæ are a family of twenty-four genera, distinguished by having a bony support for the angle of the pre-operculum; the family includes two sections, one with distinct scales, and the other with rudimentary scales, or none at all. Among the genera are the widely distributed Sebastes; Scorpæna, characterised by having a groove on the occiput; Tænianotus, which has the dorsal fin continuous with the caudal fin; Enneapterygius, which has three separate dorsal fins; Amphiprionichthys, in which the pre-operculum and operculum are small, and do not cover the gill membrane; and Synancidium, Synanceia, and Pelor, in which the head is of irregular and monstrous form. *Pelor filamentosum* is from Mauritius. Pterois has the spines and rays of the fins elongated and branched. These, with the other genera in the family, are mostly from tropical seas, especially the Archipelago of the Indian Ocean. They comprise some of the ugliest of known fishes. The large development of the pectoral fin, and the existence of pectoral appendages, give them at first sight some resemblance to the Gurnards.

FAMILY X.—POLYCENTRIDÆ.

The Polycentridæ include two genera of carnivorous fresh-water fishes from Tropical America. The lateral line in them is absent, and the teeth are very small. Monocirrhus has a barbel to the mandible, which is absent in Polycentrus; both genera have a long spinous anal fin.

FAMILY XI.—TEUTHIDIDÆ.

The Teuthididæ are a family formed for a single genus of herbivorous fishes frequenting the tropical parts of the Indian Ocean, and adjacent seas, and the west coast of the Pacific. The ventral fin has a spine both on its inner and outer margins.

Dr. Günther's second great division of the Acanthopterygian fishes is termed Beryciformes; it comprises the one family Berycidæ.

FAMILY XII.—BERYCIDÆ.

These fishes have the body compressed and elevated; the head has large mucus cavities covered with thin skin. The type genus Beryx has some of the species limited to the sea about Madeira, and others occurring in the Australian region. The opercular bones are serrated, but the pre-operculum has no spine. The scales are of the ctenoid pattern, usual in the family. In the genus Monocentris the scales are large, bony, and form an armour to the body.

The third division is named Kurtiformes; it includes

FAMILY XIII.—KURTIDÆ.

These comprise two genera of East Indian fishes, characterised by having a long anal fin, and one dorsal fin, which is rather short. The colour of the genus Pempheris is usually reddish-brown, or violet-brown, with bright coloured fins, and various spots on the body. The tail vertebræ in this genus gradually become more elongated posteriorly; the abdominal vertebræ are very short.

The fourth division, Polynemiformes, includes

FAMILY XIV.—POLYNEMIDÆ.

There are three genera—Polynemus, from Indian Seas; Pentanemus, from the west coast of Africa and the Caribbean Sea; and the genus Galeoides, from the river Niger and adjacent coast of Africa. This group has two short dorsal fins, which are remote from each other, and several appendages below the pectoral fin, which are entirely free and jointed. The mucus system in the head is well developed, and the air-bladder is sometimes absent, sometimes attains a large size, and is occasionally excessively minute in species nearly allied to each other.

The Sciæniformes include only

FAMILY XV.—SCIÆNIDÆ.

Of the Sciænidæ there are thirteen genera, some temperate and some tropical, with a few species inhabiting the fresh waters of America, Africa, and the East Indies. There are no filaments in the

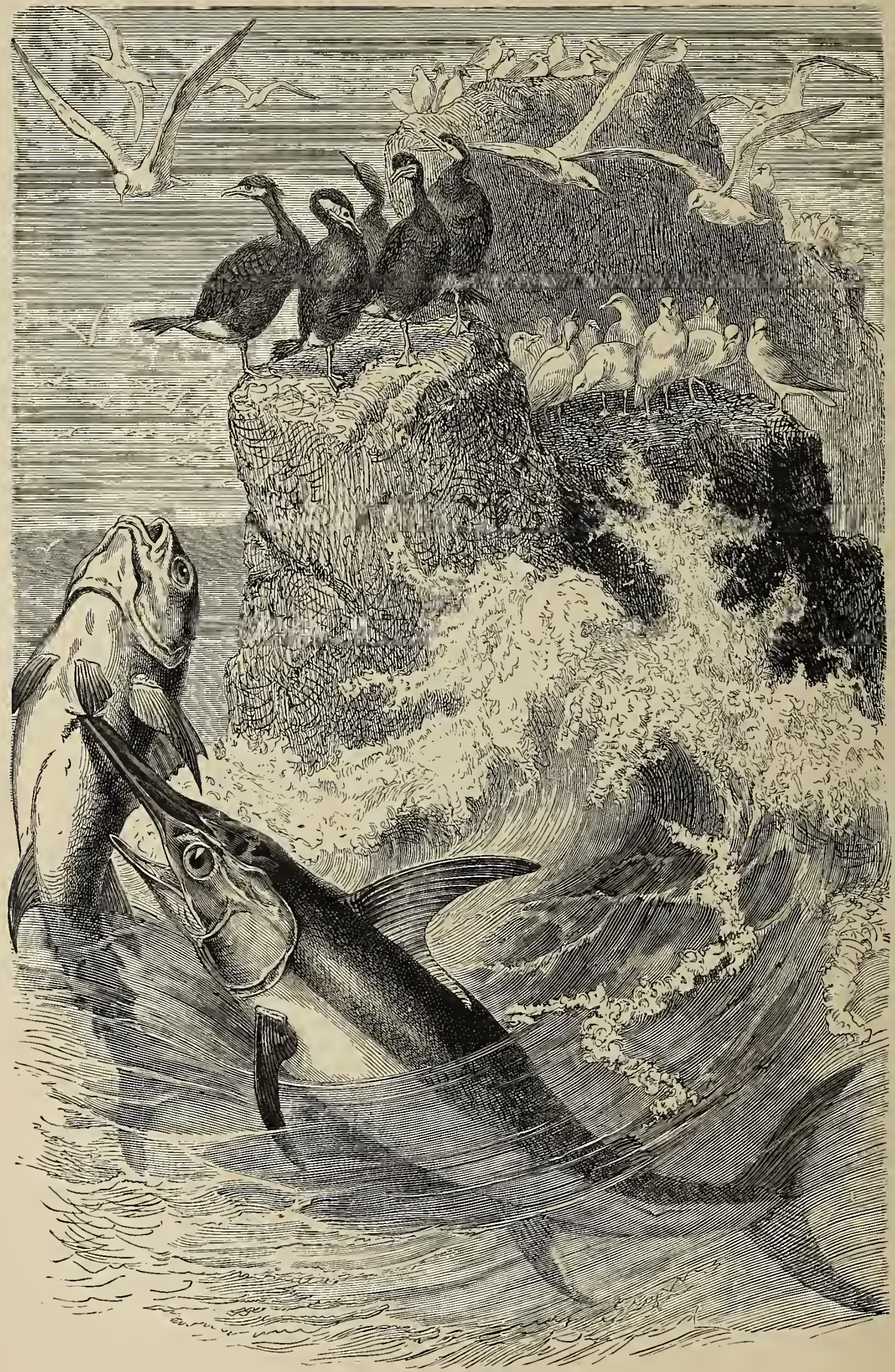
pectoral region, but the mucus system of the head is well developed. The soft dorsal fin is much more developed than the spinous dorsal, or than the anal fin. The air-bladder, which is sometimes absent, usually has greatly elongated appendages.

In the British seas there are two representatives of this family, the Umbrina cirrhosa, which ranges into the Mediterranean, where it is common, and extends as far south as the Cape Seas, and secondly the *Sciœna aquila*, commonly known as the Maigre. It rarely attains a length of three feet, but has been taken more than six feet long. It is a strong fish, and difficult to get into small

THE MAIGRE.

boats. The otolites, or ear bones, are larger in proportion to the size of the fish in this species than in any other. Its head has always been highly valued by the epicure, and was formerly presented as a tribute to the magistrates of Rome. Yarrell quotes the history of the head of one of these fishes. This head was presented to the nephew of Pope Sextus X., and he in turn gave it to one of the cardinals; from him it passed to his banker, to whom he was under obligations; and the banker presented it to his mistress. Its wanderings were followed by a man whose industry was rewarded at last by a share in the feast. This story forms much of the underplot of Beaumont and Fletcher's *Woman-hater*. The air-bladder in this species, as indeed in the whole genus, gives off processes all round its margin, which branch and subdivide into a perfect fringe. The fins are brown, the body bluish-white below, and greenish-brown above.

The division Xiphiiformes include only

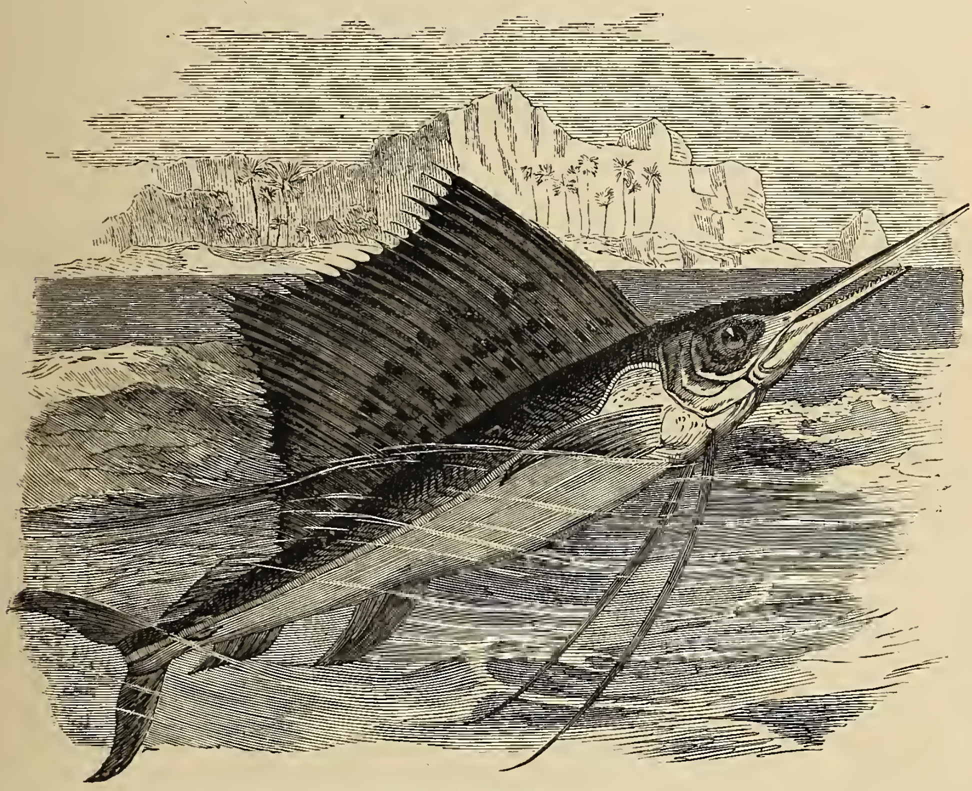


51 THE COMMON SWORD-FISH.

FAMILY XVI.—THE XIPHIIDÆ, OR SWORD-FISHES.

Of these there are two genera. Xiphias, the Common Sword-fish, abounds throughout the Mediterranean Sea and the European Seas, and extends along both sides of the Atlantic. The second genus, named Histiophorus, comprises the Flying Sword-fishes, which reach quite as large a size as the British type, and are distinguished by the enormous size of the dorsal fins. The Common Sword-fish (*Xiphias gladius*) in these seas sometimes reaches a length of ten feet, and then the sword in front of the orbit of the eye measures three feet five inches. It has once been taken in the river Nen, below Peterborough.

It has often been met with in Scotland, and ranges into the Baltic. Captain Crow is answerable



THE FLYING SWORD-FISH.

for the celebrated story of all hands being called up at three o'clock in the morning near the Hebrides to witness a battle between some Sword-fishes and Fox Sharks on the one side, and an immense Whale on the other. Almost every captain on the east coast professes to have seen an exactly similar conflict. It is well known that the sword is sometimes driven into the bottom of a ship. Dr. Leach records finding small Sword-fish in the stomach of a large one, but Scottish specimens contained the kind of Cuttle-fish called the Calamary.

The young Sword-fish is eaten on the shores of the Mediterranean. The sword in the upper jaw is depressed and flat, and extends far in advance of the lower jaw. In small specimens the dorsal fin is high and greatly elongated, and the lower jaw is relatively much longer than in the adult. The allied genus Histiophorus is also devoid of scales, but the skin contains slight dermal ossifications. This genus, unlike Xiphias, is supplied with small teeth in the jaws and on the palatine bones.

The seventh division, the Trichiuriformes, also includes but one family, in which there are seven genera.

FAMILY XVII.—TRICHIURIDÆ.

These fishes are characterised by having the body elongated, like a band, and have several strong teeth in the jaws, or on the palate. The dorsal and anal fins are long, and formed of many rays. Some forms are naked, others have minute scales; the tail is sometimes furnished with little fins. These fishes chiefly inhabit the seas between the Tropics, and extend into temperate regions, such as the Mediterranean, and are represented in our own seas by the Scabbard-fish (*Lepidopus caudatus*) and the Silvery Hairtail (*Trichiurus lepturus*).

The Scabbard-fish is only occasionally met with on our own shores. It has pointed and cutting teeth, two round scales in place of ventral fins, and a third triangular scale behind the vent. These are the only scales on the body. The dorsal fin commences at the nape of the neck, and extends the length of the body. The largest specimens are five to six feet long, and weigh, without the intestines, six pounds. There are forty-one abdominal vertebræ, and seventy-one in the tail. Trichiurus is a very rare visitor to the British coast, but is taken in the West Indies and Atlantic coasts of America. It has no scales, and the tail terminates like a whip. The spines of the anal fin are hidden beneath the skin. The ventral fins are represented by a pair of scales.

The Cotto-scombriformes is another division, including fourteen families of fishes.

FAMILY XVIII.—ACRONURIDÆ.

These are herbivorous fishes from the tropical seas, and include five genera which have one dorsal fin with several prominent spines, and one or more bony spines on each side of the tail. The teeth, which are always closely set in a single series, are sometimes lobate. The intestine is greatly convoluted.

The second section of this division includes the bulk of the fishes allied to the Scombroids.

FAMILY XIX.—CARANGIDÆ.

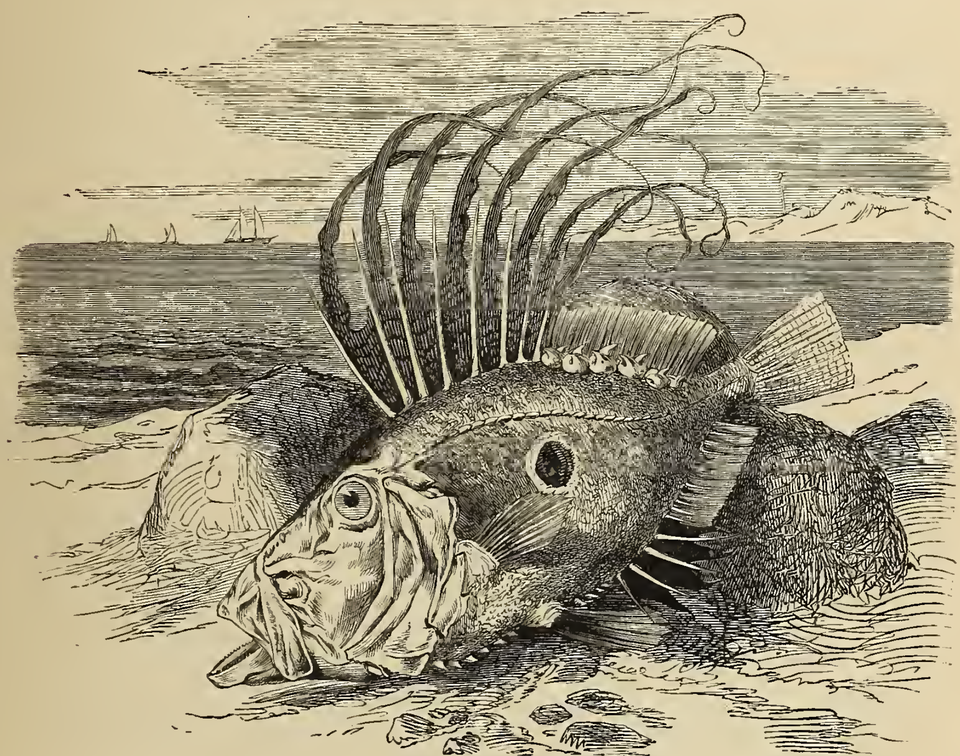
These fishes have ten vertebræ in the abdomen and fourteen in the tail. The soft dorsal and anal fins are of nearly equal extent, and the body is compressed and oblong. The best known member of this group is the Horse Mackerel (*Trachurus trachurus*), which occurs on the temperate coasts of Europe, and ranges, by way of the Cape of Good Hope, through the Indian Seas, to New Zealand, and along the western coasts of America. It is often known as the Scad. It has been caught in the Bristol Channel with the seine net in July, when following the fry of the Herring. It regularly visits the coasts of Cornwall and Devonshire in schools. It makes its appearance in May, and becomes more abundant as the season gets warmer. Ten thousand have been taken at a single cast of the seine on the Cornish coast. When following the Sand Launce, which is a favourite food with these fishes, they frequently come so near to the shore as to be taken by hand. They are not often eaten, though salted in some parts of Cornwall. The flavour is said to be inferior to that of Mackerel, though somewhat resembling it. They reach a length of twelve inches. They are largely fed upon, when young, by sea-birds, and Couch describes the multitude of gulls which pursue them so that there is no room on the surface of the sea for more, and the last comers can alight only on their comrades; while the gulls thus feed from above, the diving birds hunt the fishes from beneath.

The first dorsal fin has eight bony rays, the second dorsal fin is long. There is a small fin with two rays in front of the anal; the colour is usually dusky green on the back. The lateral line is armed with plates, which towards the tail are elevated into a ridge.

FAMILY XX.—CYTTINA.

This family comprises three genera of Scombroid fishes, well represented in these waters by the *Zeus faber*, commonly known as the John Dory, which is distributed round the Atlantic coasts of Europe, extends into the Mediterranean, and is known from the Australian Seas. The body is greatly compressed and oval; the jaws of the large head can be greatly extended; the small teeth are placed in a single row in each jaw. The spines of the first dorsal fin are very long, and the membrane between the spines is produced into very long, slender filaments. The second dorsal fin has its rays short. The anal fin has its first spinous rays elongated. A row of spiny

scales extends along the bases of the dorsal and anal fins on each side. The body is usually a pale olive-brown, with a large circular spot, nearly black, upon the middle of the side. This fish is most abundant in the summer and autumn. Couch records that he has taken from the stomach of one Dory twenty-five Flounders, three Father-lashers, and five stones from the beach. Usually it is a sluggish fish, but at times becomes active in pursuit of prey. Pilchards, the young of the Sea Bream, and the common Cuttle-fish are favourite items of food with it. It has always been highly valued for the table. It was, we believe, Archbishop Whately who declared that the proper companion for John Dory was Ann Chovy. The largest examples mentioned by Couch have a length of twenty-two inches and a weight of eighteen pounds. When dying the colours fade, but are regained when the fish is dead. The ingenious inventors of legends have disputed whether



THE JOHN DORY.

it was not the Dory rather than the Haddock which St. Peter took from the Lake of Gennesaret and marked with his finger and thumb while taking the tribute money from its mouth. Other authorities in the matter of legends maintain that while St. Christopher, wading through an arm of the sea, was carrying the Saviour he caught a Dory and left the impressions from his hand on its sides as an everlasting memorial to be handed down to the fish's posterity.

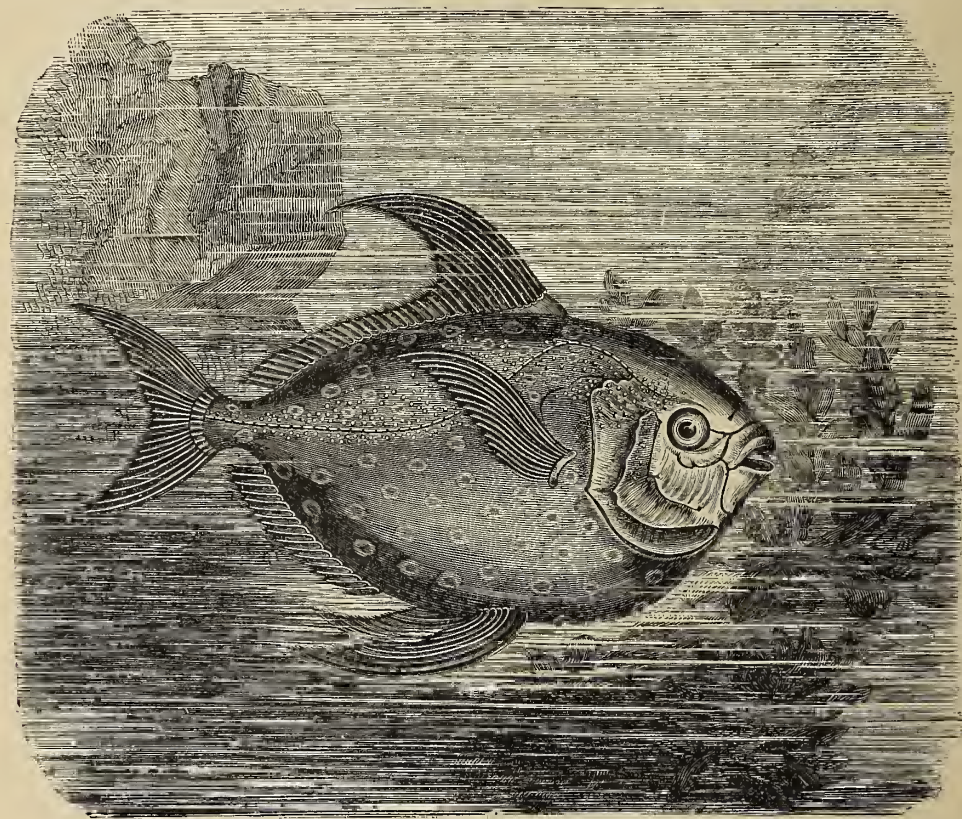
FAMILY XXI.—STROMATEINA.

This family is represented in the British seas by the Black-fish. In this group the sharp margins of the jaws are bordered with minute teeth, and though the palate and tongue are smooth, the œsophagus is armed with numerous bony teeth, which are barbed. The Black-fish (*Centrolophus pompilus*) is a rare visitor to the British coast. Couch obtained specimens thirty-two inches long, though its size is generally smaller. The flavour is delicious. The colour is usually black. A second British species (*Centrolophus Britannicus*) is described by Dr. Günther. Its stomach was found to be full of seaweed, and Couch states that the bones of the head and back were as soft as cartilage. The colour is brown, and the species is distinguished by its great length relatively to the height, and

by the great length of the dorsal fin, which extends between the head and tail. The caudal fin is forked.

FAMILY XXII.—CORYPHÆNINA.

This family has no teeth in the œsophagus. It includes nine genera, most of which occur in the Mediterranean and Eastern seas, and among other fishes Ray's Bream and the Opah. The Ray's Bream (*Brama Raii*) ranges from the Cape Seas northward into the Mediterranean and along the British coast. It is about seventeen inches long, exclusive of the fins, and five inches and a half deep. The tail is deeply divided, and the dorsal and anal fins are elongated and have



THE OPAH.

the first few spines produced beyond the others. The pectoral fins are long. The Opah (*Lampris luna*) is a remarkable type, with a compressed, elevated body, covered with small scales, which are deciduous. The fins are all red; there is no spinous portion to the dorsal fin; the ventral fins are placed behind the middle of the body. The back and sides are a rich green with purple and gold reflections; the body becomes yellowish-green or bluish below, and is covered with white spots. Its flesh is red or yellowish, and is said to have a sweet and rich flavour. Individuals attain a large size, but the specimens usually captured do not reach a length of four feet. It is well known in the North Atlantic, and enters the Mediterranean.

FAMILY XXIII.—NOMEINA.

The members of this family are scombroid fishes, with an oblong body covered with cycloid scales, having two dorsal fins, of which the soft dorsal is the more developed. The family includes six genera, among which are Gasterochisma, remarkable for having a deep fissure on the abdomen, in which the long and broad ventral fin can be completely concealed. The only species, *Gasterochisma*

melampus, is from New Zealand. The genus Nomeus has a similar characteristic, but the ventral fin is attached to the belly by a membrane.

FAMILY XXIV.—SCOMBRINA.

This is an important family, including among other fishes the Mackerel and the Tunny. There are always two dorsal fins, the spinous fin being less developed than the soft dorsal fin. In one genus the spinous dorsal becomes modified into a sucking organ, which is situated on the head. The genus Scomber inhabits nearly all the temperate and tropical seas, but is absent from the temperate coasts of South America.

THE MACKEREL.*

Hardly any fish is better known in the South of England than the Mackerel. It spawns in June, and then comes into shallow water, and 550,000 eggs have been counted in a single female. When the fish are young, under six inches long, they are termed "Shiners;" they are half grown by November, and retire into deep water at the approach of winter. Their growth is very rapid. The ordinary size ranges to a length of about fifteen inches and a weight of about two pounds, though the fish are sometimes longer and heavier. They are in the best condition in May and June. Yarrell remarks that, owing to the necessity that the fish should be eaten fresh, they were first allowed to be cried on Sundays through the streets of London in 1698, and that the practice continues to the present time. Their abundance varies: in 1807 they were sold in Billingsgate at seven shillings each; at Dover, in 1808, they were sold at sixty a shilling; and at Brighton in the same year the school was so great that it was impossible to pull the fish in, and fish and nets sunk together. Mackerel are taken in every month of the year, but the great shoals begin to move into the English Channel from the deep waters of the Atlantic in January. In the migration the males precede the greater part of the females. They reach the Shetland Isles in August, and remain in that neighbourhood about a month. A few Mackerel of small size occur in the Baltic, and they reach the coast of Norway.

This fish is exceedingly voracious, and feeds upon the fry of other fishes. It ranges along the European coast into the Mediterranean, where it is often of small size and dry in flavour. It extends across the Atlantic, and is found on the American coast in corresponding latitudes. The scales of the Mackerel are exceedingly small; there is no air-bladder. The back, as is well known, is bluish and marked with about thirty wavy transverse streaks of a blackish colour. Couch mentions that occasionally a lobe of roe has been found lying between the usual pair of lobes of milt, so that the sexes are sometimes united in one individual. The fish are captured sometimes with the hook, baited with a bright shining object, but more frequently they are taken with the seine net.

At Brighton and along the Chesil Bank the fishing is carried on by means of the ground seine net, which can be used whenever the bottom is smooth, and there is a beach on which it can be landed. The meshes of the net are small, and it is not nearly so deep at the two ends as in the middle. Each end or wing is bordered by a pole fastened to the ropes on the back and foot; and to this pole a long rope is fastened, to be used for hauling in the net to the shore. When the seine is to be shot one of these drag-ropes is left on shore in charge of some of the party, and the other rope with the nets is rowed out to sea and back again in a large sweep, the net being thrown over as they go along. On landing, the fishermen divide and haul in the net, bringing the two ends together; then the middle of the net, which is called the bunt, is drawn on shore, and contains whatever fish have been intercepted.

The Spanish Mackerel (*Scomber colias*) is occasionally taken on the Cornish coast, and occurs on the Atlantic shore of North America, and in the Mediterranean. It is inferior to the common Mackerel for table, and is distinguished by having a larger head and spotted sides. There are large scales on the pectoral region, and, according to Dr. Günther, it possesses an air-bladder. There are probably one or two other British species, and several species occur in the Red Sea and seas of Japan and the Malay Islands.

Another important fish of this family is known to us as the Tunny (*Thynnus thynnus*).

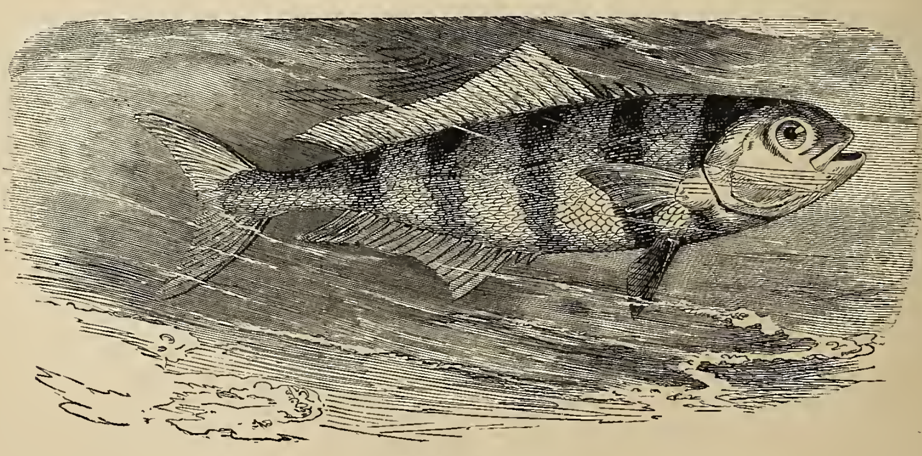
* *Scomber scomber.*

The body of the Tunny is much thicker than that of the Mackerel; the teeth are rather small, and exist in the jaws and on the palatine bones and vomer. The pancreatic appendages are extremely numerous, and the air-bladder is absent in some species of the genus. The scales of the pectoral region form a distinct covering for the throat. There is a keel on the middle of each side of the tail.

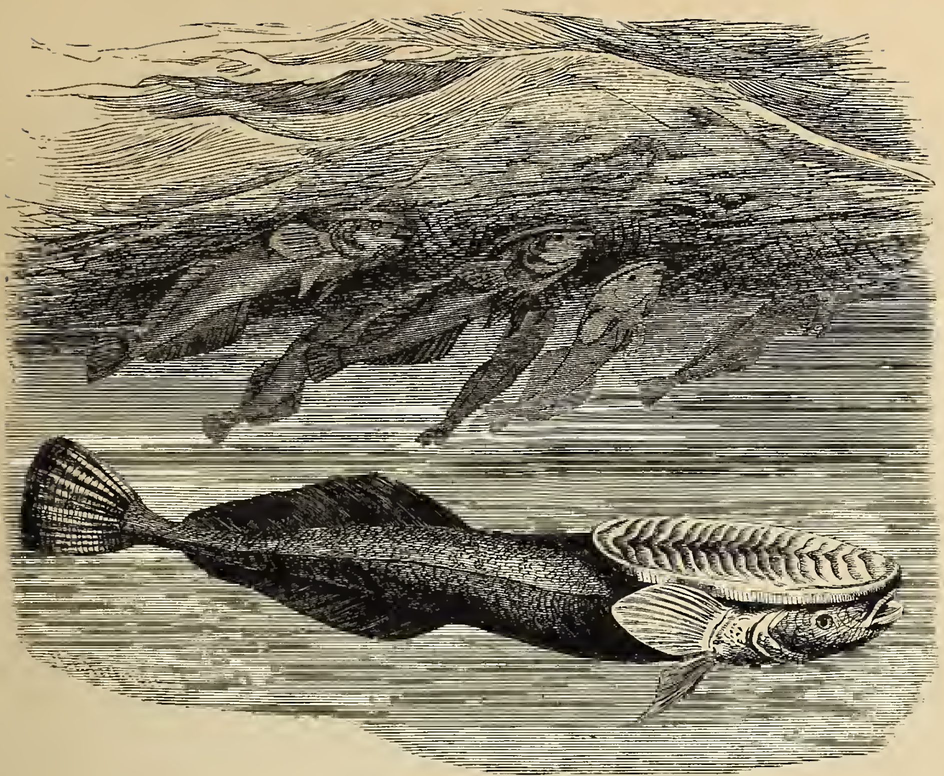
The Tunnies are widely distributed, and are especially fishes of the open ocean. The British form occurs on both sides of the Atlantic and in the Mediterranean, in which latter locality it is associated with several other species. A specimen in the British Museum, taken at Weymouth, is eight feet long. Such a fish would probably weigh five hundred pounds, but they are rarely met with of a greater length than three feet. They feed on Herrings, Sardines, Flying-fish, Mackerel, and probably many other fishes smaller than themselves. The Tunny harvest in the Mediterranean is of the utmost importance to the countries near which the fishes pass. They come in from the Atlantic in vast multitudes, and journey through the Straits of Gibraltar by way of Sicily on to the Black Sea. Toll is taken of them on every shore they pass by. After leaving the Black Sea they swim back again along the southern shore of the Mediterranean, and pass out into the Atlantic. It has been observed that the Tunny possesses so much blood that its flesh has the appearance of beef, and its temperature is as high as that of a mammal; nevertheless, it breathes by means of gills, and the heart is shaped on the plan characteristic of fishes. The colour of the skin above is dark blue, the under side of the body is greyish. The head is large and conical, and one-fifth of the length. The pectoral fin is long, and reaches to near the end of the spinous dorsal fin. The dorsal spines are rather short.

Another species of this genus, the *Thynnus pelamys*, is sometimes known as the Bonito, and sometimes called the Striped-bellied Tunny. It ranges through the warmer parts of the Indian Ocean and Atlantic, and occasionally visits our own coast. It seldom exceeds thirty inches in length, feeds on fish, especially the Flying-fish, and also eats Cuttles. It has been recognised in various parts of the British coast, has red muscles, few teeth, and a flat and thin tongue. The colour is steel-blue on the back, with four brownish longitudinal stripes on the sides of the belly. Another British species is the Germon (*Thynnus alalonga*), distinguished by the great length of the pectoral fin, which reaches beyond the end of the second dorsal fin. It is rare in the English Channel, but plentiful in the Bay of Biscay. It is stated that the fishermen of Ile d'Yeu capture thirteen or fourteen thousand in a season with hooks, which are often baited with pieces of bright tin, shining earthenware, or blue or white cloth. The Germons feed on Anchovies, Pilchards, Fying-fish, &c. The other species of this genus are met with in the Red Sea, Indian Ocean, and Caribbean Sea.

The next genus, Pelamys, has the first dorsal fin continuous with the second, and usually from seven to nine little finlets; the dorsal and anal fins are similar to those which occur in the Tunny and Mackerel. *Pelamys sarda* reaches a length of fully two feet; it is not abundant on the



THE PILOT-FISH.



THE SUCKING-FISH, OR REMORA.

British Coast, but frequents both sides of the Atlantic, and ranges throughout the Mediterranean and Black Seas. There is the same corselet of scales in this genus in the pectoral region which characterises the Tunny.

The genus Auxis is represented in these seas by a fish commonly known as the Plain Bonito (*Auxis rochei*). It has but little value as food.

The Pilot-fish (*Naucrates ductor*) has a long, somewhat cylindrical body, covered with small scales. The spinous dorsal fin is reduced to a few short free spines. The fish has a bluish colour, marked with five to seven vertical bars, which are dark and broad. It often follows ships for weeks, or even months, and it is also said to follow large sharks; and anecdotes have been recorded which would appear to indicate that the relations between these two fishes were of a friendly character. The Pilot-fish is usually about a foot long; it feeds on small fishes, and its flavour is said to be similar to that of the Mackerel.

THE SUCKING-FISH, OR REMORA.*

All the species of the genus Echeneis have a flat, oval disc on top of the head, which is formed of a number of transverse plates constituting a sucking organ, by which these fishes are capable of adhering. The border of the disc is elevated, and the water is driven out by contraction of the laminæ. The attachment, when once made, often continues after death. These fishes are brown in colour, occur in nearly all temperate and tropical seas, especially in the Pacific and East Indies. The Remora attaches itself to sharks, whales, or ships, and is carried by them for great distances. It is rarely met with in the British seas; its length is about four inches and a half. The sucking disc has a cavity for its reception excavated in the upper part of the skull.

Another well-known species is the *Echeneis naucrates*, specimens of which in the British Museum have a length of thirty-two inches. The suctorial disc is formed of from twenty-one to twenty-five laminæ; there are fourteen vertebræ in the abdomen and sixteen in the tail. The latter vertebræ are compressed and elongated.

* *Echeneis remora.*

CHAPTER V.

ORDER ACANTHOPTERYGII (*concluded*).

THE TRACHINIDÆ—Uranoscopus—Star-gazers—The Greater Weever, or Sea Cat—The Lesser Weever—THE MALACANTHIDÆ—THE BATRACHIDÆ—THE PEDICULATI—THE SEA DEVIL, OR ANGLER—Its Voracity—The Genus Malthe—COTTINA—THE MILLER'S THUMB, OR RIVER BULLHEAD—THE SEA SCORPION, OR FATHER LASHER—The Gurnards—THE CATAPHRACTI—THE COMEPHORIDÆ—THE DISCOBOLI—The Lump-sucker, or Lump-fish—The Sea-Snail—THE GOBIIDÆ—THE OXUDERCIDÆ—THE CEPOLIDÆ—THE TRICHONOTIDÆ—THE HETEROLEPIDINA—THE BLENNIIDÆ—The Wolf-fish, or Cat-fish—The Butterfly Blenny—The Shanny—The Viviparous Blenny—THE ACANTHOCLINIDÆ—THE MASTACEMBELIDÆ—THE SPHYRÆNIDÆ—THE ATHERINIDÆ—The Sand Smelt—THE MUGILIDÆ—The Grey Mullet—THE GASTEROSTEIDÆ—STICKLEBACKS—The Three-spined Stickleback—Its Pugnacity—The Nest—The Ten-spined Stickleback—The Nest—The Fifteen-spined Stickleback, or Sea Adder—The Nest—THE FISTULARIDÆ, OR PIPE-FISHES—THE CENTRISCIDÆ—The Trumpet-fish, or Bellows-fish—THE GOBIESOCIDÆ—THE PSYCHROLUTIDÆ—THE OPHIOCEPHALIDÆ—The Calling-fish—THE LABYRINTHICI—Supra-branchial Organ—The Climbing Perch—THE LUCIOCEPHALIDÆ—THE APHREDODERIDÆ—THE LOPHOTIDÆ—THE TRACHYPTERIDÆ—THE NOTACANTHI.

FAMILY XXV.—TRACHINIDÆ.

THE Trachinidæ are a family of carnivorous fishes comprising four or five groups of genera which feed at the bottom and are met with on the shores of nearly all seas. The first group, Uranoscopina, includes several genera which have the eyes on the upper surface of the head, which is defended with bony plates. The body in these fishes is sometimes naked and sometimes partly covered, or even entirely covered, with small scales. The best known genus, Uranoscopus, comprises about ten species, which are familiarly termed star-gazers. They are said to bury the snout in the sand and capture their prey as it crawls slowly by them. *Uranoscopus scaber* occurs in the Mediterranean and off the Canary Islands. The second group, Trachinina, has the eyes more or less at the sides of the head, which is not armoured. Seven of the genera have the body covered with scales, and three are devoid of scales. These fishes are represented in the British seas by the Weevers, of which there are two species. The operculum in the Weevers is prolonged into a remarkable spine, which is used as an offensive weapon. The ventral fins are under the throat, and the anal fin extends the length of the under side of the body. The first dorsal fin, placed behind the head, contains six or seven spines; and the second dorsal fin is elongated like the anal fin, but does not extend quite as near to the tail. The fish frequently buries itself in the sand, where it may be left covered up between tides.

The *Trachinus draco*, or Greater Weever, is sometimes known as the Sea Cat. It generally measures about a foot to eighteen inches in length. It is sometimes taken with a trawl net, and sometimes on deep sea lines. The fishermen are liable to be wounded by its spines, injuries from which affect the limb as high as the shoulder, so that it becomes necessary to rub the wound with oil and laudanum. In France and Spain the fishermen are required to cut off the spines before the fish, which is excellent eating, is sent to market. It is tenacious of life, and, in common with other fish which frequent the bottom, keeps good for several days after it is taken from the water. Couch mentions having found in their stomachs Gobies, the Sand Launce, a Squid, and various small fishes and shrimps. It extends along the European coast, throughout the Mediterranean, and along the African coast to the Cape seas.

The Lesser Weever (*Trachinus vipera*) is frequently found on the sandy coast of Lincoln and Norfolk. Its habits are similar to those of the Greater Weever. It spawns in spring, while the Greater Weever spawns in summer. Its usual length is four or five inches; the colour is yellowish-brown, and the body is relatively deeper than that of the Great Weever. It frequents the western coasts of Europe and the Mediterranean. Other genera of this group, such as Percis and Sillago, are found in Eastern seas; Eleginus, Epicopus, and Percophis are genera found on the American coasts. Other genera are Arctic and Antarctic.

The third group, Pinguipedina, includes two genera of which the species are chiefly American. The fourth group, Pseudochromides, comprises half-a-dozen genera which have a similar distribution.

FAMILY XXVI.—MALACANTHIDÆ.

The Malacanthidæ are a tropical family represented by one genus having very long dorsal and anal fins, and an operculum armed with a spine.

FAMILY XXVII.—BATRACHIDÆ.

This is a small family of tropical fishes, which feed on the bottom, and includes some species which are naked and others covered with scales. The *Batrachus didactylus* is sometimes met with in the German Ocean, but more frequently between the coast of Portugal and the Guinea Coast of Africa. It is remarkable for the circumstance that the air-bladder, which is divided into two lateral portions connected by a transverse tube, has but a small internal cavity, owing to the immense development of muscle attached to the sides of each portion of the bladder.

THE URANOSCOPUS SCABER.

FAMILY XXVIII.—PEDICULATI.

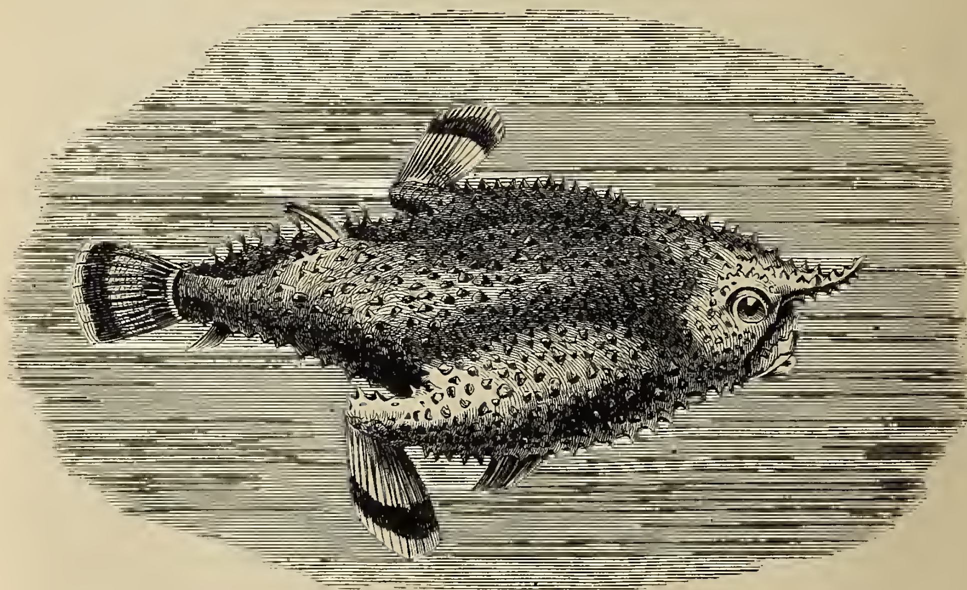
The Pediculati comprise some of the ugliest of fishes, among which may be instanced such genera as Lophius and Malthe. In these fishes the carpal bones are prolonged, so as to form a sort of arm for the support of the pectoral fins, which sometimes, as in the genus Malthe, have the aspect of legs, and give the fish a frog-like appearance. In our own seas there is only one representative of this remarkable group, the majority of which are tropical.

THE SEA DEVIL, OR ANGLER.*

The great breadth of the head and anterior part of the body, no less than its depressed form, gives this fish somewhat the aspect of a gigantic tadpole. It is met with on almost all parts of the

* *Lophius piscatorius.*

British coast, and along the shores of Europe, and ranges southward in the Atlantic to the Cape of Good Hope. On the head of this voracious animal are two or three detached rays of the dorsal fin, which are extended as long filaments and terminate upward in bright shining surfaces. Keeping close to the bottom, the fish is said to stir up the mud by moving its ventral and pectoral fins, and at the same time elevates these appendages; then, as small fishes approach to examine the bait, they are immediately seized by the Angler. It has been known to seize Codfish and Conger Eels after those fishes had taken the fisherman's hook. Couch records that nearly three-quarters of a hundred of Herrings have been taken from the stomach of a single Angler, in a condition fit for market, and that another individual similarly yielded up twenty-one Flounders and a Dory, which also found their way to market; so that the digestion of the fish is apparently very slow. On one occasion some boys thrust a board into the mouth of a large Angler, which was seen in shallow



THE MALTHE VESPERTILIO.

water, and the fish allowed itself to be drawn into their boat without releasing its hold. One Angler has been seen endeavouring to swallow a Gull, and another had seized the Great Northern Diver (*Colymbus glacialis*); but its appetite is so little discriminative that it has swallowed the cork buoys of a crab-pot, the floating barrel fixed to the head-rope of a pilchard-net, and the iron grapnel of a fisherman's boat. This fish reaches a length of about five feet. The roe, which is small, is computed to contain about a million and a half of eggs; but the young fish are so rare as to be almost unknown. The gape of the mouth is extremely wide; the teeth are arranged in alternate series, and are constantly renewed from behind. The aperture for the gills is a small foramen placed just behind the pectoral fin.

Dr. Günther remarks that the species of the genus Antennarius, which inhabit the seas between the Tropics and feed on floating seaweed, are enabled to fill the large stomach with air so as to sustain themselves on the surface of the water, and thus become driven by currents over wide regions of the ocean. The genus Malthe has the nasal bones prolonged over the forehead into a prominent process, below which is a tentacle capable of being retracted into a cavity. The skin has a rough aspect from being covered with conical protuberances. The snout in *Malthe vespertilio*, which inhabits the Atlantic coast of America, varies in length, being sometimes as little as one twenty-fifth of the total length of the fish, and sometimes as much as one-sixth of the length in Brazilian

specimens. There are eight vertebræ in the abdomen and eleven in the tail. Some of the anterior and posterior vertebræ are elongated.

FAMILY XXIX.—COTTINA.

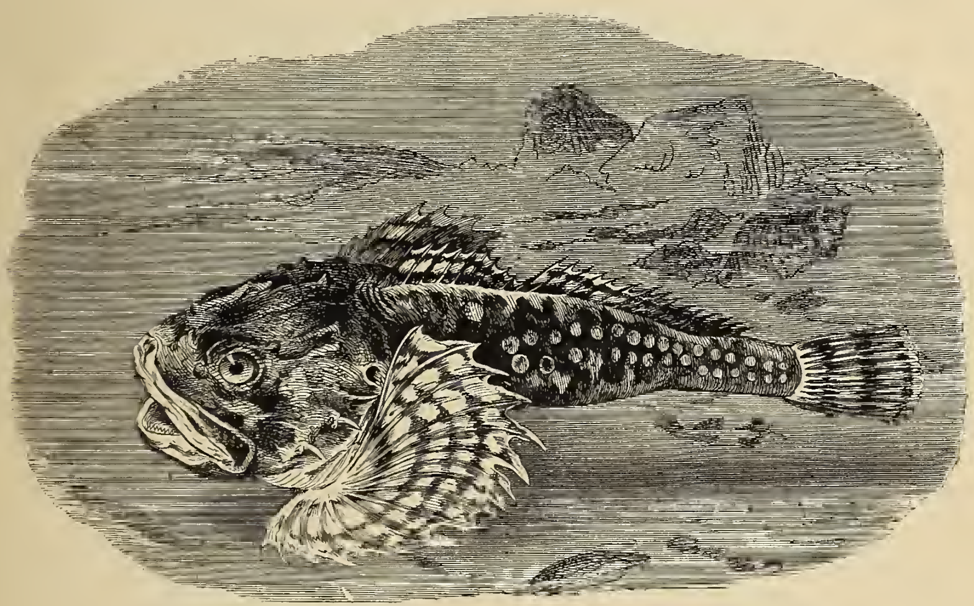
The family Cottina comprises the Gurnards and about eighteen genera of allied fishes, some of which have the body naked, while in others it is covered with ordinary scales, and in a few defended with scales like bony plates.

THE MILLER'S THUMB, OR RIVER BULLHEAD.*

This little fish grows to a length of three or four inches, and derives its name of Bullhead from the head being large and broad and swollen at the cheeks. It is white on the underside, but brownish-black above, with small black spots and bands over the back and sides. It feeds on the larvæ of water-insects and the eggs and young of other fishes, and is readily caught with a small red worm. It is extremely active, darting about from place to place, and undergoes many changes of colour under exertion and after feeding. It is found not only in all the sandy and gravelly streams of our own country, where it hides itself under stones, but throughout Europe and in the north of Asia. Its skin is slippery. The female is said to carry the eggs on her breast after spawning, but some writers state that after depositing them in the gravel she broods over them till they are hatched. Cuvier found the Bullhead to be an excellent bait for the Eel. Yarrell, quoting James Wilson, states that the flesh of the Bullhead becomes red when boiled, and is excellent eating.

THE SEA SCORPION, OR FATHER LASHER.†

This is a marine Bullhead found on the coasts of Britain and the German Ocean; it is also met with in the Baltic. It has the head armed with spines, two above the snout, four on the crown, and three on the pre-opercular bones. The skin is usually naked, and black with grey marblings.



THE SEA SCORPION.

The males are more richly coloured. It lives on the smaller crustacea, and is often caught in the shrimp-nets. It is commonly found near to shore, where it is often left uncovered. The species enters estuaries and sometimes ascends rivers. The *Cottus bubalis* closely resembles the Father Lasher, and like that species grows to a length of four or five inches, but it is more slender, has four opercular spines,

* *Cottus gobio.* † *Cottus scorpius.*

has the lateral line armed with bony plates, and affects deep water. According to Couch, its colour is a mottling of red and brown. It is frequently found in lobster-pots. A variety of it occurs on the coast of California and the Gulf of Georgia. All these fishes have the fins well developed.

The other British representatives of this family are the Gurnards, which form the genus Trigla. The head is elevated, with the eye near its summit; its surface is bony and marked with radiating lines; the body is covered with small scales. There are three filaments in front of each pectoral fin, which, when the animal is at rest, have the aspect of legs. There are bristle-like teeth on both the jaws and on the vomer. The air-bladder is usually divided into two parts, which are furnished with lateral muscles. The stomach forms a pouch. There are several British Gurnards, but they also range round the western coasts of Europe and into the Mediterranean. The Red Gurnard (*Trigla pini*) is a common British fish, reaching a length of about fourteen inches. It feeds on crustacea, is readily caught with a trawl, and is excellent food, especially during the winter months. The head has a squarish form, the ventral fins are placed under the throat, and all the fins are well developed. The Streaked Gurnard (*Trigla lineata*) is also red, with large pectoral fins, which are more or less spotted with blue. It has a shorter head than the Red Gurnard, and is rather smaller. The Sapphirine Gurnard, or Tub-fish (*Trigla hirundo*), has extremely small scales. The space between the eyes is concave; the colour is brownish-red, and the broad pectoral fins are margined with blue. The snout is rather elongated. It lives among stones, and feeds on shell-fish, crabs, and other fishes. The air-bladder in this species is divided into three lateral lobes. In some European languages the grunting or crowing noises which these fishes produce have gained for them the name of Sea Cocks. *Trigla lyra* is also known as the Piper; it is another Red Gurnard, chiefly met with in the West of England. The name Piper is in allusion to the sounds emitted when the fish is handled. This species reaches a length of two feet. The Grey Gurnard (*Trigla gurnardus*) is by far the most abundant British species. Its head is more depressed than in the other species; the lateral line carries a series of bony plates, which are white, and each has a rough crest. The pectoral fin does not reach as far back as the beginning of the anal fin, which distinguishes it from the other British species. The colour is brownish-grey, spotted with white.

FAMILY XXX.—CATAPHRACTI.

The next family, the Cataphracti, is a group of genera distinguished by having the body completely encased in bony plates, or scales, which are marked with keels. This family is represented in the British seas by *Agonus cataphractus* and *Peristethus cataphractum.* The former, sometimes known as the Armed Bullhead, and sometimes called the Pogge, is a little fish about six inches long, met with in the northern parts of Europe. It frequents the mouths of rivers; has a very small mouth, that is incapable of taking an ordinary hook; has a wide head, defended with bones and armed with spines. The body is covered by rows of large strong scaly plates. The colour is brown.

The *Peristethus cataphractum* is a red fish known as the Armed or Mailed Gurnard. It has a large head and remarkably long snout, the extremity of which is forked laterally. The body is octagonal and covered by a series of large plates, the middle of each of which is longitudinally keeled. The fins are well developed.

FAMILY XXXI.—COMEPHORIDÆ.

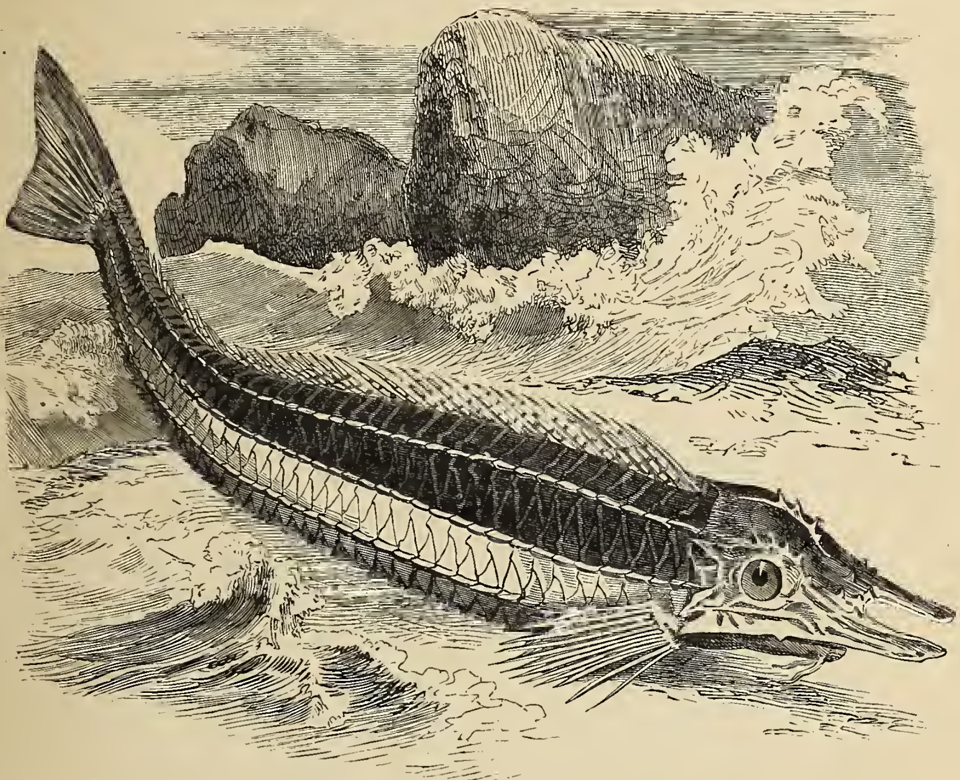
The last family of the Cottoscombriformes is termed Comephoridæ. It is represented by a single species—*Comephorus baikalensis*, a fish of uniform green colour, having the pectoral fin longer than the head, and chiefly remarkable, according to Dr. Günther, for the soft condition of the skeleton, and the circumstance that the opercular bones are separated. There are eight vertebræ in the abdomen and thirty-five in the tail.

The ninth division of this order is the Gobiiformes, and comprises three families.

FAMILY XXXII.—DISCOBOLI.

The Discoboli are a remarkable group of carnivorous fishes living upon the sea bed. They are familiarly known as the Suckers, from the circumstance that the space between the ventral fins is occupied by a round disc which has a cutaneous margin and a base of bone. There are only two genera in this family, which are named Cyclopterus and Liparis.

The Lump-sucker, or Lump-fish (*Cyclopterus lumpus*), has a wide range round the northern coasts of Europe and the opposite coast of North America. It is a heavy-looking, ugly fish, with a rough body, covered with tubercles, of which there are four longitudinal series larger than the others. Couch states that the Seal is one of its most formidable enemies, and after capturing the fish the mammal strips off the skin before swallowing its prey. They are also fed upon by Sharks and Skates. The Lump-fish commonly has a length of ten inches. It feeds on small crustacea and young fish. The female deposits her eggs in a hollow, or sort of nest, and after they have been fertilised the male is said to keep close watch over them. After the young are hatched, the



THE ARMED OR MAILED GURNARD.

young fishes attach themselves by their suckers to the sides and back of the male, who carries them away with him into deep water. The spawn is of a pink colour. The male is much smaller than the female. There is very little lime in the bones of the fishes of this genus.

The Sea Snail (*Liparis vulgaris*) is often known as the Unctuous Lump-sucker. It is a northern fish, which in our own seas is rarely more than four inches long. It has been stated to ascend rivers, but is usually found under stones near low water. Soon after death it dissolves on exposure to the sun. The skin is smooth, and the colour variable, often marked with irregular longitudinal dark lines on a pale-brown body.

FAMILY XXXIII.—GOBIIDÆ.

The Gobiidæ are a large family of fishes, the genus Gobius alone containing more than 150 species, while the family includes more than twenty genera. They are fishes having an elongated body, which is sometimes naked. They are all carnivorous, and live at the bottom. Some of the species occur indifferently in salt and fresh water. They are found throughout temperate and tropical regions. The body is always scaly, with a short head; the teeth are generally small, sometimes with distinct canines at the corners of the mouth. The ventral fins unite below the

hinder part of the pectorals into an oval disc, which, however, is not attached to the body of the fish, and hence does not form a sucking organ. The species are all small, and vary both in shape and colour. The Black Goby (*Gobius niger*) reaches a length of five inches, but is rare, and only found on the rocky parts of our coasts. It has the habit of constructing a nest. The *Gobius paganellus* is a brown fish, with darker marblings, and fins which have a bluish or blackish tinge. The Spotted Goby (*Gobius minutus*) differs from the other species in wanting the silk-like pectoral fins, and in the length of the ventral fins. The White Goby (*Latrunculus albus*) is a small fish, only known in the south of Scotland. This species is transparent.

FAMILY XXXIV.—OXUDERCIDÆ.

Some of the fishes of this family have the eyes very prominent and the eyelids well developed. One of these—Periophthalmus—has the muscles of the pectoral fins well developed, so that they can be used for progression upon land when these fishes, and those of the allied genus Boleophthalmus, come on shore to hunt terrestrial insects. One division of the family, including the genus Amblyopus, has the two dorsal fins united into one. It is chiefly confined to the East Indies, China, and Japan, but has one species ranging to the west coast of South America. Another section of the genus, distinguished by having the ventral fins widely separate from each other, is represented in the British seas by the Dragonet or Skulpin (*Callionymus lyra*), a species in which the brilliant colours and fin-spines undergo some changes with age and sex. The first dorsal spine is enormously elongated; the body does not reach the length of a foot. In the Dusky Skulpin the spines of the first dorsal fin are much less elongated. In this fish there are eight abdominal vertebræ, and thirteen in the tail. Other Skulpins occur in the Mediterranean, Chinese, Indian, and Malay Seas.

In the Chinese *Oxuderces dentatus* the ventral fins are entirely wanting.

The tenth division of this order, the Blenniiformes, is a group comprising six families.

FAMILY XXXV.—CEPOLIDÆ.

This family is known from the one genus Cepola, chiefly found in the Japanese waters, but represented in the Mediterranean and on the British coasts by the Band-fish (*Cepola rubescens*). It is known in the Mediterranean from its brilliant red colour as the Red Riband and the Fire-flame. Its body is compressed from side to side, and elongated; its length is from fifteen to twenty inches; the scales are extremely small; the jaws carry on their outer margin a row of conical pointed teeth, with a short second row in the front part of the mandible. The eyes are large; nose short; and the lower jaw frequently the longer. The ventral fins are just under the pectoral fins, and the air-bladder is placed behind the other internal organs. The dorsal and anal fins are very long, and formed of soft rays which are continuous with the small pointed caudal fin. These fishes are said to feed on seaweed, crustacea, and small shells, and are eaten by the Cod and other voracious fishes, but are not valued for food by man.

FAMILY XXXVI.—TRICHONOTIDÆ.

The Trichonotidæ are a small family of carnivorous fishes from the Indian Archipelago and New Zealand, and which are only known from two species.

FAMILY XXXVII.—HETEROLEPIDINA.

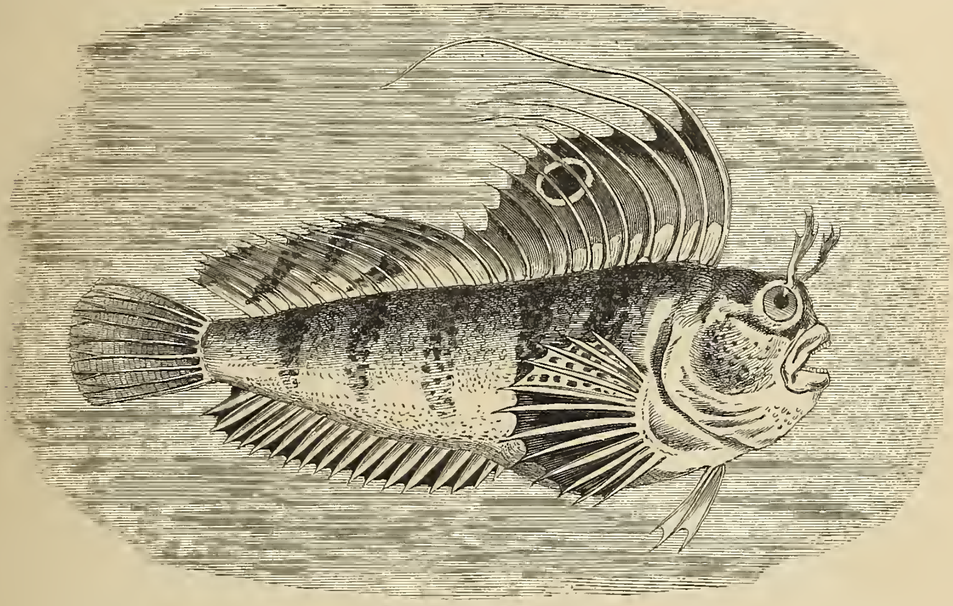
This is another small family from the northern parts of the Pacific, comprising the genus Chirus—which has several lateral lines—and the genera Ophiodon, Agrammus, and Zaniolepis. In all these fishes the anal fin is very long.

FAMILY XXXVIII.—BLENNIIDÆ.

The Blenniidæ are a large family of carnivorous fishes, sometimes inhabiting fresh waters, but generally living on the bottom near the sea-shore. They are widely distributed over the world, and comprise upwards of thirty genera. The majority of the species are from tropical seas, though some of the genera have a distinct northern habit. There are comparatively few British representatives of the tribe.

The Wolf-fish, or Cat-fish (*Anarrhichas lupus*), is found on the temperate coasts of northern Europe and North America, and ranges northward to Greenland. Armed with formidable teeth, and having eyes which are placed much like those of a Cat, its aspect is ferocious. It fights desperately when captured, and is usually killed with blows on the head. The fish has a disagreeable smell, but the skin, which is covered with slime, is sometimes made into bags. The liver is said to be delicious, and the flesh is valued for food in Norway and Sweden. It is often taken on lines set for Cod, for its usual food consists of mollusca and crustacean animals, which the molar teeth on the palate and hinder parts of the lower jaws enable it easily to crush. It is a rapid swimmer, but lives on the bottom among the rocks. Its usual length does not exceed three feet, but individuals are sometimes as much as six or seven feet long. The colour is brownish-grey, crossed with bands, and speckled with dark spots; the belly is white. The dorsal fin extends the length of the body, and the anal fin runs along its posterior half. There are no ventral fins, and the pectoral fin is broad and rounded, and like the caudal fin.

The fishes forming the genus Blennius have a general resemblance to the Cat-fish, owing to the shortness of the snout and the way in which the dorsal and anal fins extend along the body. There are several species in our own seas, all of which, except the Smooth Blenny, have crests on the head. *Blennius gattorugine* is rather rare with us, but more abundant farther south and in the Mediterranean. It seldom exceeds a length of nine inches. The Butterfly Blenny (*Blennius*



THE BUTTERFLY BLENNY.

ocellaris) has a remarkably short snout, with long curved teeth in both jaws. The spinous part of the dorsal fin is long, and has on its hinder part a large round black spot with a white edge. It is a small species, rarely more than three inches long, lives among weeds, and feeds on shell-fish and minute crustacea. It also ranges southward into the Mediterranean. Montagu's Blenny is a somewhat smaller species, and has a transverse crest on the head. The Smooth Blenny (*Blennius pholis*) is commonly known as the Shanny; it has no appendage on the head, the dorsal fin is distinctly notched and not continuous with the caudal fin; the colour is olive-green, with irregular black spots. One that was kept in confinement devoured spiders and caterpillars, molluscs, roast beef, mutton, fowl, and, in fact, any food that was offered to it. Its colour always became dark when the water was changed. Its eyes are capable of moving independently of each other. The eggs are of amber colour and semicircular outline. Its long incisor teeth are used to separate Limpets, Mussels, and other shell-fish from the rocks. It is capable of living out of water for many days

where the ground is moist, and can endure fresh water for a short time. It is rarely five inches long.

Some species of the genus Salarias have the intestine three times as long as the fish. The species of the genera Clinus and Cristiceps are viviparous. The Butter-fish (*Centronotus gunellus*) is a northern species, ranging south to the coasts of Britain and France. It has a low dorsal fin running along the back, and is covered with a thick mucous secretion. The length rarely exceeds seven inches. The colour is a dappled purplish-brown. Another well-known form is the Viviparous Blenny (*Zoarces viviparus*), which ranges round the German Ocean and into the Baltic. The length is about six or seven inches, and the young, which sometimes number three hundred at a birth, are an inch and a half long when born. The body is long and compressed from side to side, with the form usual among the Blennies. The colour is pale brown. The males are smaller than the females and less numerous. The fish is not valued for food, and when boiled its bones become green.

FAMILY XXXIX.—ACANTHOCLINIDÆ.

The Acanthoclinidæ are represented by a single New Zealand species (*Acanthoclinus littoreus*), distinguished by the great number of spines in the long anal fin. It has several lateral lines.

FAMILY XL.—MASTACEMBELIDÆ.

The Mastacembelidæ include fishes from the fresh waters of the East Indies, having an Eel-like body covered with very small scales, and wanting the ventral fins. Dr. Günther remarks that these fishes are Eels in which parts of the dorsal fins are spinous.

The eleventh division is the Mugiliformes, in which three families are comprised.

FAMILY XLI.—SPHYRÆNIDÆ.

The Sphyrænidæ are carnivorous fishes, represented by the one genus Sphyræna, which is widely distributed in the tropics, especially in Eastern seas, and represented in the Atlantic and Mediterranean by *Sphyræna vulgaris.* In this fish there are two dorsal fins well separated from each other, and the ventral fins are well under the abdomen. All the species have the teeth strong, and possess twenty-four vertebræ. The air-bladder bifurcates in front.

FAMILY XLII.—ATHERINIDÆ.

The Atherinidæ are fishes with a feeble dentition, two dorsal fins, the ventral fins abdominal, and numerous vertebræ in both the caudal and abdominal regions. Several species of the genus Atherina enter fresh waters. In the genus Tetragonurus the scales are striated and keeled. This group is represented in the British seas by *Atherina presbyter*, where it is known as the Sand Smelt. It is chiefly caught in the estuaries and creeks of the south coast, especially in sandy bays. It is a well-flavoured fish. It is often taken at Brighton, where it is eaten in the winter. A broad silver stripe runs the length of its side, and covers the fifth and parts of the two adjacent rows of scales. This fish bites readily at any bait; it ranges south to Madeira and the coast of Algiers. The *Atherina hepsetus* is found in the Mediterranean, Black Sea, and Canaries; the *Atherina lacustris* is met with only in some of the smaller lakes of Italy. The other species of the genus are widely distributed.

FAMILY XLIII.—MUGILIDÆ.

The Mugilidæ are a small family of three genera, but include a large number of species. These fishes have twenty-four vertebræ, and two short dorsal fins. In the genus Mugil there are no true teeth in the jaws, and in the two other genera the teeth are small. The species of Mugil are migratory, pass a part of the year in the sea, abound in temperate and tropical regions, and feed on the organic substances which are mixed with mud and sand. The pharynx forms a sort of filter, the pharyngeal bones rejecting everything but the fine sediment. These pharyngeal bones are supported on masses of fat, so that they are somewhat elastic. The second portion of the stomach resembles that of birds; the intestines are greatly convoluted, measuring seven feet in length in a specimen thirteen inches long. *Mugil cephalus* is met with in the Mediterranean and in the lakes and rivers of North Africa, but some species are confined to fresh waters, like the *Mugil nepalensis* of Nepaul.

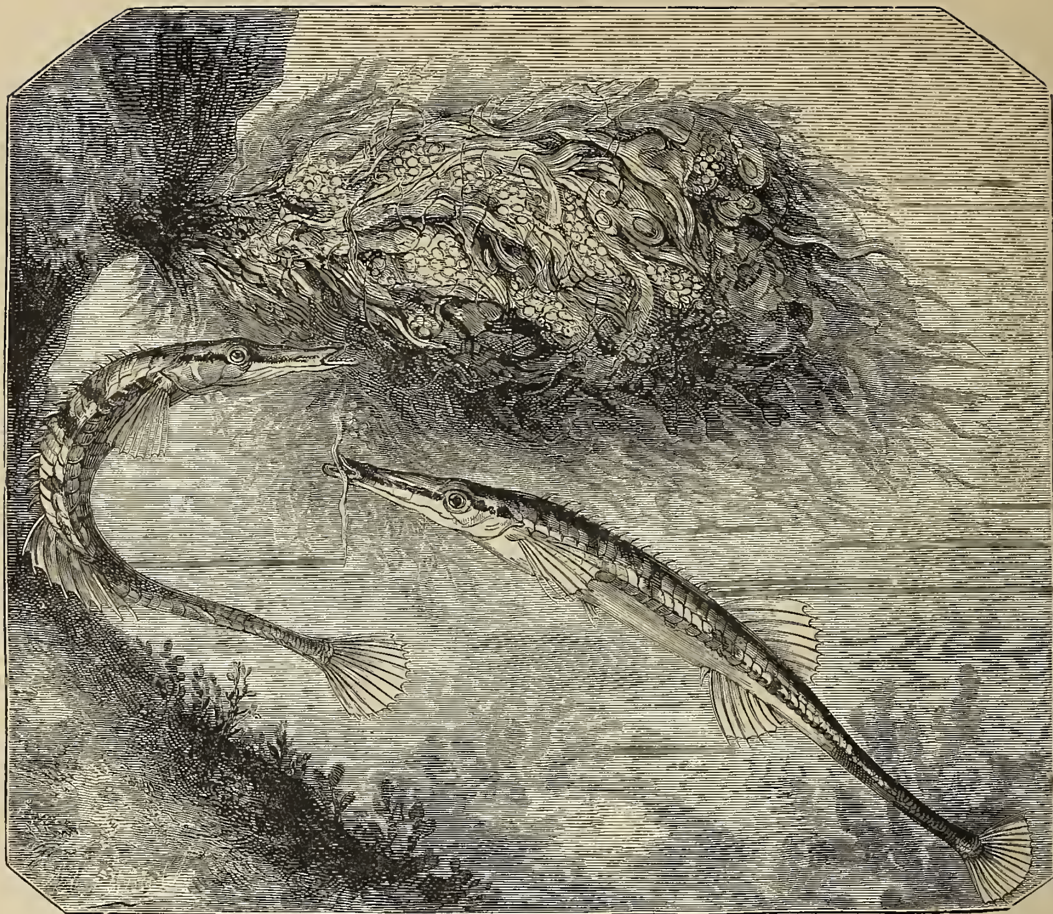
The Common Grey Mullet (*Mugil capito*) occurs all round the coasts of Europe, and as far south as the Cape of Good Hope, and has also been met with in the Nile and fresh-water lakes of Tunis. It is the most common of the European Grey Mullets, but, like all the other species of the genus, it is very variable. It is usually seen near to the shore, and in our own country always returns with the tide, when it ventures up rivers. When kept in salt-water ponds the fish become so tame as to assemble at a signal given them. When enclosed in the seine net the Grey Mullet often leaps over the head line, and is followed by all its associates, in the same way that Sheep follow their bell wether. They feed on soft and fat food, especially such as is slightly decayed. In Guernsey the Mullet has been kept in fresh-water ponds, and found to improve in weight even more rapidly than the other sea fishes which have been experimented upon in the same way. The colour upon the top of the head and back is greyish-blue, while the sides and belly are silvery, with parallel dusky lines running along the length. The *Mugil septentrionalis* is found on the British and Scandinavian coasts, and reaches a length of twenty-three inches. A third British species (*Mugil curtus*) is occasionally captured in the English Channel.

The twelfth division is the Gasterosteiformes, a small group of fishes comprising the Sticklebacks and the Pipe-fishes of the family Fistularidæ.

FAMILY XLIV.—GASTEROSTEIDÆ.

The Sticklebacks all belong to the genus Gasterosteus, of which eleven species and several varieties are known. These are small fishes of elegant form, mostly limited to fresh or brackish water.

THE TEN-SPINED STICKLEBACKS.



THE FIFTEEN-SPINED STICKLEBACK.

In this country there are two fresh-water species, the Three-spined Stickleback and the Tinker, or Ten-spined Stickleback, and one marine species, the Fifteen-spined Stickleback.

The Three-spined Stickleback (*Gasterosteus aculeatus*) is so named from having three spines in the middle of the back, in the position usually occupied by the first dorsal fin. The body is moderately elongated and compressed; the ventral fins have one strong spine; the middle of the body is covered with plates, but there are no scales. It is a furious fighter, but, as is so often the case in the animal kingdom, the females are peaceful, and it is only the males who do battle. These fishes are remarkable for their parental instinct, which leads the male to build a nest and watch carefully over the young. The nest is made of stalks of grass and other substances, which are cemented together with mucus, either from the mouth or from the skin. The bottom of the nest is first laid, and afterwards the sides and top are built. According to Signor Costa, as quoted by Yarrell, a small hole is left on one side of the nest. The colours of the male now become extremely brilliant. After a good deal of coaxing he drives the female into the nest. She makes her way out on the opposite side of the nest to that by which she entered, leaving the eggs behind, The male fertilises the eggs, and is said to frequently bring to the nest a succession of females. He then watches for a month over the nest, which is about the size of a shilling, or a little larger. and is placed at the bottom of the stream in about six inches of water. The eggs are of a bright yellow colour. The length of this species rarely exceeds three inches. In some parts of the country, when abundant, the fish have been collected for manure. They live from two to three years. Yarrell mentions that in Kamschatka and Rupert's Land they are stored as winter food for dogs, that hogs

are sometimes fed on them, that oil is extracted from them in Eastern Russia, and they are sometimes made into fish soup.

The Ten-spined Stickleback (*Gasterosteus pungitius*) has the row of dorsal spines much lower than in the foregoing species. There are no plates on the sides of the body in this species. The male at the breeding-time becomes velvety-black. The nest of this Stickleback is built upon aquatic plants, or among their roots, and has been compared to the nest of a Wren.

The Fifteen-spined Stickleback, or Sea Adder (*Gasterosteus spinachia*), is a marine species, five to seven inches long, which never ascends rivers, and makes its nest of seaweed or coralline, and guards the eggs like the fresh water species. It has the same rapacious habits, and feeds on the eggs and fry of fishes, worms, and other marine animals. Mr. Richard Q. Couch carefully watched the method of nest-making, and found that the materials were bound together with an elastic thread, which resembled silk, which hardens by exposure to the water, and is seen under a magnifier to consist of several smaller threads united together; but the way in which it is secreted has not been determined. The eggs are a bright amber colour. Couch records that on one occasion a nest as large as the fist had been built in the hollow formed by the untwisted strands of a rope which hung in the sea. The embryo when first hatched is unlike the parent, the head being round and blunt instead of elongated, and the pectoral fins are relatively large, while the dorsal and anal fins extend along the body to unite with the caudal fins. The ventral fins are at first absent. The colour of the fish is variable, sometimes reddish-brown, sometimes dark green. It is met with on all the northern coasts of Europe.

FAMILY XLV.—FISTULARIDÆ.

The Fistularidæ are fishes having a greatly elongated body, and the head is even longer than in the Fifteen-spined Stickleback. In the Stickleback family the ventral fin is joined to the pubic bone, but in the Fistularidæ these fins are remote from the pubic bones. In the genus Fistularia the body is without scales, has no free dorsal spines, has the caudal fin forked with the two middle rays prolonged into a filament. There are only two species of Fistularia known—the *Fistularia tabaccaria* and *Fistularia serrata.* The head is a long depressed tube, one-third of the total length of the body; there are bony shields immediately below the skin protecting the anterior part of the trunk. The lateral line runs along the length of the dorsal shield, and then bends downward to the middle of the side. There are four vertebræ united together in the neck into a solid mass, forty-nine vertebræ in the abdomen, and thirty-three in the tail. There are no ribs. The teeth are small, and occur on the jaws, palatine bones, and vomer. The *Fistularia tabaccaria* is from the tropical parts of the Atlantic and Indian Oceans; the *Fistularia serrata* ranges from the coast of Mozambique to China and Australia.

The second genus of this family—Aulostoma—has the body covered with small scales, has a series of feeble isolated dorsal spines, wants the filaments to the tail, and has rudimentary teeth. One species is from the Caribbean Sea, the other ranges from the coast of Mozambique to the Western Pacific. The neck vertebræ are blended together as in Fistularia.

The thirteenth division is named Centrisciformes, a family comprising two genera.

FAMILY XLVI.—CENTRISCIDÆ.

The genus Centriscus has the body scaly, or covered with prickles, and the genus Amphisile is without scales, but has a bony cuirass, which is attached to the spine of the first dorsal vertebræ.

The species of the genus Centriscus frequent Australia, China, and the southern part of Europe and the Mediterranean. The *Centriscus scolopax,* which reaches our own south coast, is commonly known as the Trumpet-fish, or Bellows-fish. Some authors have termed it the Sea Snipe. The body is compressed and oblong, with the snout prolonged like a tube, which terminates in a narrow toothless mouth. There are two small dorsal fins placed far back. The second spine of the first dorsal fin is long, very strong, and has its hinder border serrated. The body is covered with small spiny scales; there is no lateral line. There are several bony plates on the back and abdomen; the ventral fins are as close together as in the Gobies, and they are received into a groove on the belly. There are eight vertebræ in the abdomen, which are strong and large, and the transverse processes

THE TRUMPET-FISH OR BELLOWS-FISH.

of the first four have their extremities united. The colour of the fish is a rose or reddish-green on the back and silvery on the belly. The flesh of this species is eaten, and considered to be good. Dr. Günther remarks that the allied genus Amphisile may be considered as a Chelonian form among fishes.

The fourteenth division, Gobiesociformes, includes two families of naked fishes which have no spinous dorsal fin.

FAMILY XLVII.—GOBIESOCIDÆ.

The Gobiesocidæ have an adhesive sucker between the ventral fins, and the Psychrolutidæ have no ventral fins. The family Gobiesocidæ comprises nine genera, and though the sucker is similarly placed to the sucker of the Discoboli, its structure is different. In those fishes the ventral fins occupy the centre of the disc and form its base, but in these the fins are widely separated from each other, and only margin the disc, which is about one-third of the whole length of the fish, and has its border chiefly formed by cartilaginous expansions of the coracoid bones. Dr. Günther remarks that the posterior or coracoid portion has the skin divided into many polygonal plates, which are wanting in the anterior part which lies between the roots of the ventral fins. The genera are widely distributed; Chorisochismus is from the Cape Sea, Sicyases from the coast of Chili, Gobiesox from the Caribbean Sea and west coast of South America, Crepidogaster from the coasts of Australia, while Lepadogaster is found in the Mediterranean, and ranges northward to the Scandinavian coast. Of this genus there are three British species—*Lepadogaster gouanii,* usually known as the Cornish Sucker, the *Lepadogaster candollii,* or Connemara Sucker, and *Lepadogaster bimaculatus.* These are small fishes, varying from an inch to three inches in length. In the Cornish Suckers the vertical fins are continuous with the caudal fin, but in the Bimaculate Sucker the vertical fins do not reach so far back. The colour is usually more or less red, but is variable. In all these fishes the intestine is short, straight, and wide.

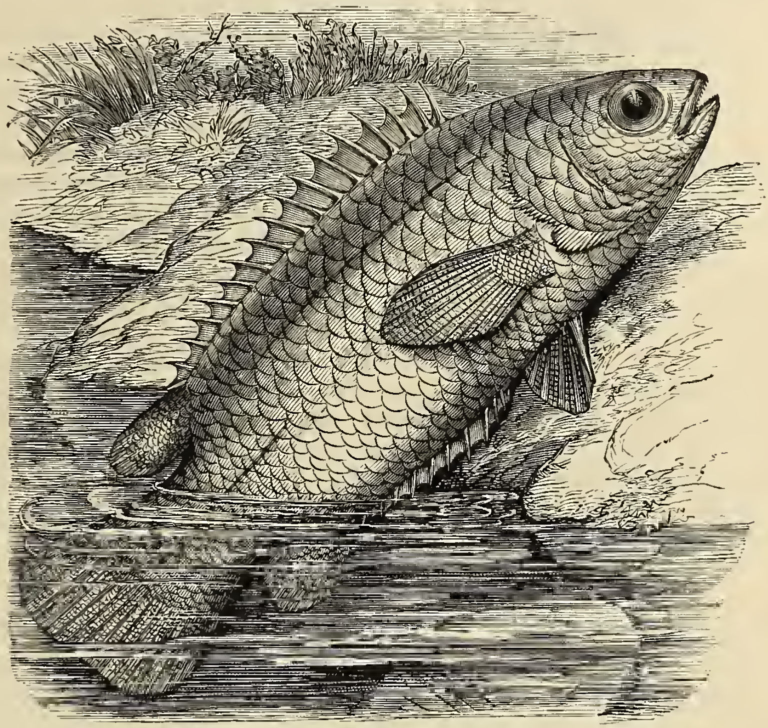
FAMILY XLVIII.—THE PSYCHROLUTIDÆ.

The *Psychrolutes paradoxus*, from Vancouver Island, is the only fish in the Psychrolutidæ, a family which unites many characters of other families which have been here described.

The fifteenth division of the order is the Channiformes, an interesting group of two genera of fresh-water fishes from the East Indies. Some species are limited to India, Siam, and China; other species are found in the rivers of Sumatra and Borneo.

FAMILY XLIX.—THE OPHIOCEPHALIDÆ.

The Walking-fish (*Ophiocephalus*) has the body long and nearly cylindrical in front. The flattened head is covered with shields above, and the body with scales of moderate size. There are fine teeth on the jaws, vomer, and palatine bones, suitable for grasping the many small land animals which fall a prey to these fishes. There is a cavity connected with the gill-chamber which retains water so as to moisten the gills, but there is no distinct organ for this purpose, such as is found in the Climbing Perch. These fishes become buried in the mud when the pools dry up, and are often found in India by digging at a depth of two or more feet below the dry surface. There are fifty-one vertebræ in the abdomen and sixty-one in the tail. There is one long dorsal fin, but both it and the anal fin are without spines. Ophiocephalus possesses ventral fins, but in the genus Channa, from the fresh waters of Ceylon, the ventral fins are absent. The *Ophiocephalus striatus* is taken by the native fishermen with a long flexible bamboo as a rod, and a hook baited with a live frog, but these fishes are also often captured with nets. They are monogamous, and universally distributed over India. The Ophiocephalus breeds twice a year, in June and December. The male then bites off the ends of water-weeds and constructs a nest with his tail amongst the vegetation. After the ova are deposited the male keeps guard over them, but his place is taken by the female if he should happen to be killed. After the young are hatched they swim a little above their parents, who defend them with great courage. None of the fishes of this family migrate. The species of Ophiocephalus are most successfully carried from place to place in mud, but they need when in water to rise to the surface to breathe air. According to Mr. Day, they are often captured in Burmah by spreading a large cloth over the mud in which they have buried themselves, when they soon become stupefied from deficiency of oxygen. Ophiocephalus falls a prey to fresh-water Snakes, the fresh-water Porpoise, and the fish-eating Crocodile (*Gavialis gangeticus*).

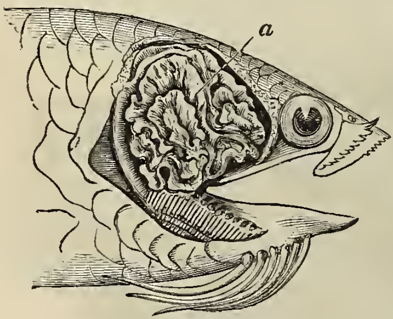


THE CLIMBING PERCH.

FAMILY L.—THE LABYRINTHICI.

The sixteenth division, termed the Labyrinthibranchii, contains two families. This family includes nine genera. The fishes have the body covered with scales of moderate size, which also extend over

the head. The gill-opening is rather narrow, and there is an organ above the cavity of the gills which is formed of thin bony laminæ, which branch and are folded so as to somewhat resemble a compound coral. This organ is placed upon the upper part of the first branchial arch, and retains a small quantity of water, which serves to moisten the gills. The fish are capable of living for some time out of water or buried in mud. Several of the species have been domesticated, and they are carried about by the Indian jugglers with their other apparatus. The various species live on small animals as well as upon vegetable substances, and have been said to mount trees to a height of several feet from the ground. One of the best known genera is Anabas, commonly called the Climbing Perch. The supra-branchial organ becomes more complicated as the fish increases in size. The length of *Anabas scandens* is generally about seven inches. It has teeth in the jaws and on the vomer. There are many spines in the dorsal fin and several in the fore part of the anal fin. The opercular bones are serrated, the air-bladder is divided posteriorly, and both portions extend to near the end of the tail. This species is of a greyish-olive colour, and is found throughout the East Indies in rivers and estuaries. Natives while fishing, according to Day, kill the Climbing Perch by biting through the vertebral column behind the head, but in this operation the fish occasionally slips down the throat, and then, owing to its spiny character, it can be withdrawn only with great difficulty. Other species occur in China and the Malay Islands. The genus Helostoma, which has the air-bladder simple, is confined to Java. Polyacanthus, like the foregoing genus, has no spines on the operculum. Macropus is a genus domesticated in China. The Gourami (*Osphromenus olfax*) is a nest-building fish of this group, with the first ray of the ventral fin greatly elongated. It is found in the fresh waters of Java, Sumatra, and Borneo. The genus Spirobranchus occurs in the rivers of the Cape of Good Hope. The genus Ctenopoma is found near the mouth of the Zambesi in pools. Many of these fishes have colours of dazzling beauty, and some of them are highly valued for food.



SUPRA-BRACHIAL ORGAN (A) OF THE CLIMBING PERCH.

FAMILY LI.—THE LUCIOCEPHALIDÆ.

Luciocephalus pulcher has a broad black band, margined below with white, running from the eye to the caudal fin, and often has round black spots on the fins and body. It occurs in the fresh waters of Borneo and some of the adjacent islands, and is the only member of its family which differs from the foregoing by having no spines in the anal fin or short dorsal fin, and by having the gill-opening wide.

The next division differs from all the foregoing in having the vent placed in front of the ventral fins.

FAMILY LII.—THE APHREDODERIDÆ.

This family includes only one species (*Aphredoderus sayanus*), which is found in many of the lakes and streams of the Atlantic coast of North America. The ventral fins are placed in the thoracic region; there is one dorsal fin, but its spinous part is but little developed.

FAMILY LIII.—THE LOPHOTIDÆ.

The eighteenth division also includes only one family, which is represented by *Lophotes cepedianus*, a fish with a riband-shaped body, with the vent near the extremity of the body, and a short anal fin behind the vent. One dorsal fin runs the whole length of the back; there are no scales. The head is elevated into a high crest; the fins are rose-coloured, but the body is silvery. It reaches a length of about five feet, and is found in the Mediterranean and the Sea of Japan.

The nineteenth division includes only

FAMILY LIV.—THE TRACHYPTERIDÆ.

These fishes have the skeleton soft, and the body elongated, strongly compressed, and without scales. The dorsal fin extends the whole length of the back, and has a detached anterior part. The anal

fin is always wanting; the caudal fin is usually directed upward. All the species frequent deep seas. Three genera have been defined. The genus Trachypterus, which has well-developed ventral fins, is represented by many species on the Mediterranean coasts of Europe, and also occurs on the west coast of South America. In our own waters it is represented by the Deal-fish (*Trachypterus arcticus*), which ranges northward to Iceland and Norway. Large specimens are six feet long and one foot high. Its body is very tender and brittle, so that it is rarely preserved. Its movements are slow, and resemble those of the Flat-fish. They are said when alive to be fat, with the sides of the body round. The sides are silvery, the high dorsal fin is red, and the caudal fin, which is directed upwards like a cock's tail, is also red. The genus Stylophorus, found in the Gulf of Mexico, has the tail terminated in an appendage like a cord, which is twice as long as the fish's body. The genus Regalecus has each ventral fin reduced to one long filament, and the caudal fin is usually absent or represented by a rudiment. Two species occur in the Mediterranean, two on the coast of Norway, while one, known as the Ribbon-fish, or Oar-fish (*Regalecus banksii*), occurs in our own seas. A specimen was taken in Yorkshire twenty-four feet long, though the usual length is about twelve feet. The colour is silvery, with irregular dark lines and spots on the anterior part of the body. The dorsal fin is red, but there is no trace of a caudal fin. The anterior twelve spines form an elevated crest behind the head. The lateral line is marked on the lower third of the body by elongated flat scales, but the skin generally is covered over with small bony tubercles. The snout is truncated, and there are no teeth in the mouth. The stomach is prolonged as a pouch, which reaches between the muscles to near the end of the tail. A specimen measuring fifteen feet and a half in length was one foot two inches deep, three inches and a half thick, and weighed 182 lbs.

The twentieth and last division of Acanthopterygian fishes is formed for

FAMILY LV.—THE NOTACANTHI.

This family includes the species of the genus Notacanthus. This group is characterised by having the dorsal fin represented by short free spines, the soft portion being sometimes entirely absent. The snout protrudes beyond the mouth. Species occur in the Mediterranean, Arctic regions, and in the Australian seas. The *Notacanthus rissoanus*, which has the nasal region prolonged into a proboscis, and has thirty or more spinous finlets on the back, is regarded by Dr. Günther as likely to form the type of a second genus.

CHAPTER VI.

THE ORDER PHYSOSTOMI.

ORDER PHYSOSTOMI—SILURIDÆ—Characters—The Various Sub-Families—The Silurus Glanis—The Melapterurus electricus—Its Electric Organs—The Genus Loricaria—Curious Feature connected with the Genus Aspredo—CHARACINIDÆ—HAPLOCHITONIDÆ—STERNOPTYCHIDÆ—Pearl-spotted Fishes—SCOPELIDÆ—Bombay Duck—STOMIATIDÆ—SALMONIDÆ—Characters—THE SALMON—Description—Climbing the Rivers—The "Leaps"—Changed Appearance after Spawning—Hatching—The Fry—Growth-Stages of the Young—The Journey to the Sea—The Salmon at Sea—Various Modes of Fishing—Largest Catches—Distribution—THE GREY TROUT—THE SALMON TROUT—THE COMMON TROUT—THE GREAT LAKE TROUT—Other Species of Trout—THE CHARR—Various Species—THE SMELT—THE CAPELAN—The Genus Coregonus—THE POLLAN—THE GRAYLING—PERCOPSIDÆ—GALAXIDÆ—MORMYRIDÆ—GYMNARCHIDÆ—ESOCIDÆ—THE PIKE—Its Size and Age—Its Voracity—Pike Migrations—The Lucie Family—Characters of the Fish—UMBRIDÆ—SCOMBRESOCIDÆ—The Genus Belone—The Garfish—The Genus Scombresox—The Saury, or Skipper—The Genus Hemirhamphus—The Flying Fish—The Genus Exocœtus—Characters—Height and Duration of Flight—CYPRINODONTIDÆ—Singular Eye Character of Anableps—HETEROPYGII—CYPRINIDÆ—Distinctive Features—The Carp—Habits—Carp Culture—Its Diet—The Crucian Carp—THE GOLD FISH—Kept as a Pet—Variation in Colour—Characters—The Barbel—The Gudgeon—The Roach—The Chub—The Dace—The Ide—The Red-eye, or Rudd—The Minnow—The Red-fin—The Spawn-eater—The Tench—The Rhodeus Amarus—The Bream—The Bleak—The "Essence de l'Orient"—The Loach—The Spinous Loach.

ORDER VI.—PHYSOSTOMI, OR FISHES WITH THE AIR-BLADDER OPENING INTO THE MOUTH.

THE Physostomi form a large division of fishes characterised by having the fin rays jointed. Sometimes, however, the first ray in the dorsal fin and in the pectoral fin are more strongly developed

than the others, and more or less ossified. The spines are never found in the ventral fins, but these fins are sometimes absent, and when present are placed in the abdominal region of the body. When the air-bladder exists it is always connected with the throat by a pneumatic duct.

This order of fishes includes, in Dr. Günther's classification, twenty-nine families. It comprises a vast multitude of genera, the Siluroid family alone including nearly 120 generic types, while among the other families are such familiar fishes as the Eels, Conger Eels, Herrings, Salmon, Pike, and Carp.

FAMILY I.—SILURIDÆ.

The Siluroid fishes never have scales, and when the skin is not naked it bears on its surface bony plates or scutes. The maxillary bones are here reduced to rudiments, and generally form the support for a maxillary barbel, so that the margin of the upper jaw is formed by the pre-maxillary bones only. The operculum is peculiar in wanting the sub-opercular bone. The air-bladder communicates with the organ of hearing by means of auditory ossicles. The dorsal and anal fins are variable in their development, and the characters from these organs, together with the positions of the nostril and of the vent, are used to subdivide the family into great groups, which Dr. Günther names Homalopteræ, Heteropteræ, Anomalopteræ, Proteropteræ, Stenobranchiæ, Proteropodes, Opisthopteræ, and Branchicolæ. Each of these sub-families is again subdivided according to the characters of the gill membranes, nostrils, lips, barbels, and positions of the fins.

The Siluroid fishes are found in the fresh waters of tropical and temperate regions, and the few which enter the sea keep near to the coast. The genus Clarias has one group of species confined to Africa and Syria, distinguished by having a prominent occipital crest which is angular behind, while in East Indian species that prominence is less developed. The best-known species is Clarias anguillaris, a fish eighteen inches long, from the Nile and West Africa. Two species from the Ganges and East Indian Archipelago have the caudal fin united with the dorsal and anal fins. As the waters dry up, these fishes make their way over the mud by help of their fins in search of water, and at the time of these migrations are readily captured. Heterobranchus is an allied genus distinguished by having two dorsal fins, the anterior supported by rays, and the posterior fatty. Its distribution is chiefly African, but one species—Heterobranchus tapeinopterus—has been found in Borneo and Banka. The number of barbels in these fishes is usually eight—two pairs on the mandibles, one pair of maxillary barbels, and a nasal pair. The species of the genus Cnidoglanis are confined to the rivers and coasts of Australia; in them the second dorsal fin is long, and is continuous with the caudal and anal fins. In the genus Chaca there are no barbels on the nostrils, and the eyes are rudimentary. The species are East Indian.

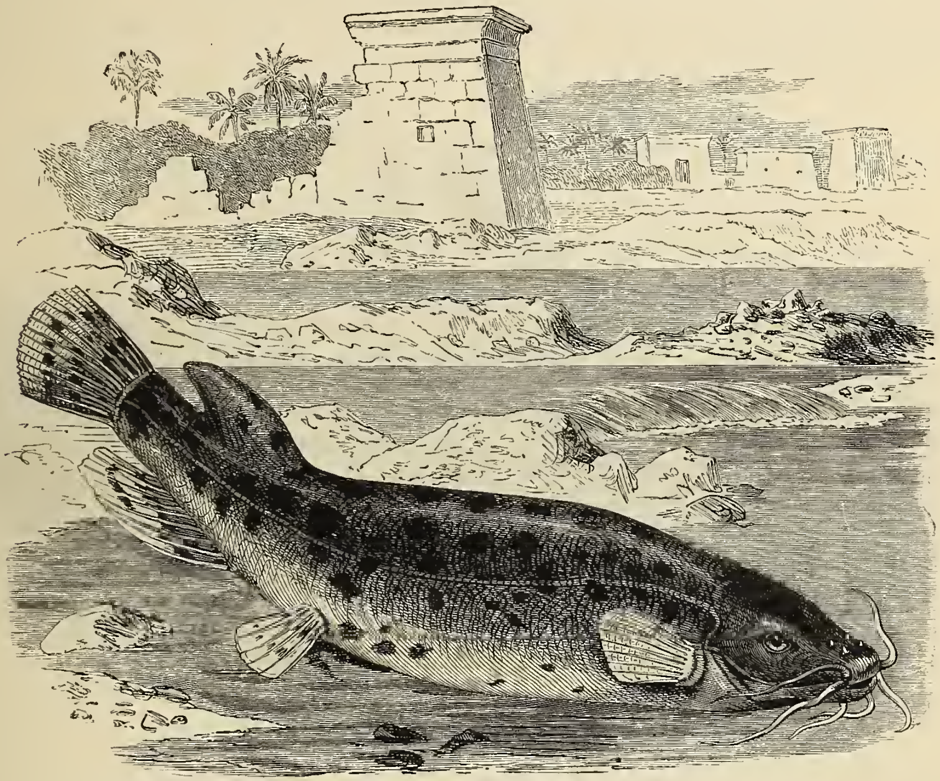
The only representative of the Siluroid family in Europe is the Silurus glanis, which occurs in the rivers of Europe east of the Rhine. It is the largest of European fresh-water fishes, and is said to have once been captured in a tributary of the Shannon. It is absent from Britain, France, Spain, and Italy. It was formerly taken in Haarlem Meer, is rare in Scandinavia, common in Prussia, Poland, Styria, the Danube, and the rivers of Southern Russia. In the river Bug it has been taken sixteen feet long. Quoting from Valenciennes, Yarrell states that a specimen captured near Thorn had the entire body of an infant in its stomach; and another example taken in Hungary is said to have contained the body of a woman having a marriage ring on her finger and a purse full of money at her girdle. Young specimens are valued for food, but are not easily captured. It is commonly found at the bottom, but rises to the surface in stormy weather.

The fat is used in dressing leather, and the air-bladder is made into gelatine. There is one small dorsal fin in this genus conspicuous for wanting the anterior spine. The anal fin, however, is well developed, and extends back, so as to unite with the caudal fin, which is rounded.

The head and body are covered with soft skin, and the colour is a mottled brownish-olive. The pectoral fin has a stout spine for its first ray, and this is slightly serrated at the free end. The vent is placed behind the ventral fins. There are four barbels on the mandible, and one, greatly elongated, is attached to each maxillary bone.

Other species of Silurus occur in Afghanistan, Cochin China, Malabar, China, Japan, and Formosa. The genera allied to Silurus, which form Dr. Günther's second sub-family, or Heteropteræ, are all confined to the old world. The third sub-family is South American. The genus Helogenes has the eye very small, and covered over with the skin, as is the case in several other Siluroid fishes. Hypophthalmus has the eye behind, and below the angle of the mouth; the mouth is devoid of teeth.

The genus Amiurus is confined to North America, though one species ranges to China. The palate is toothless, and there are only eight rays in the ventral fin. Many genera of Siluroid fishes are covered in the region in front of the dorsal spine with heavy armour, which frequently has a granulated surface. This armour is well seen in the genus Rita, in Ælurichthys



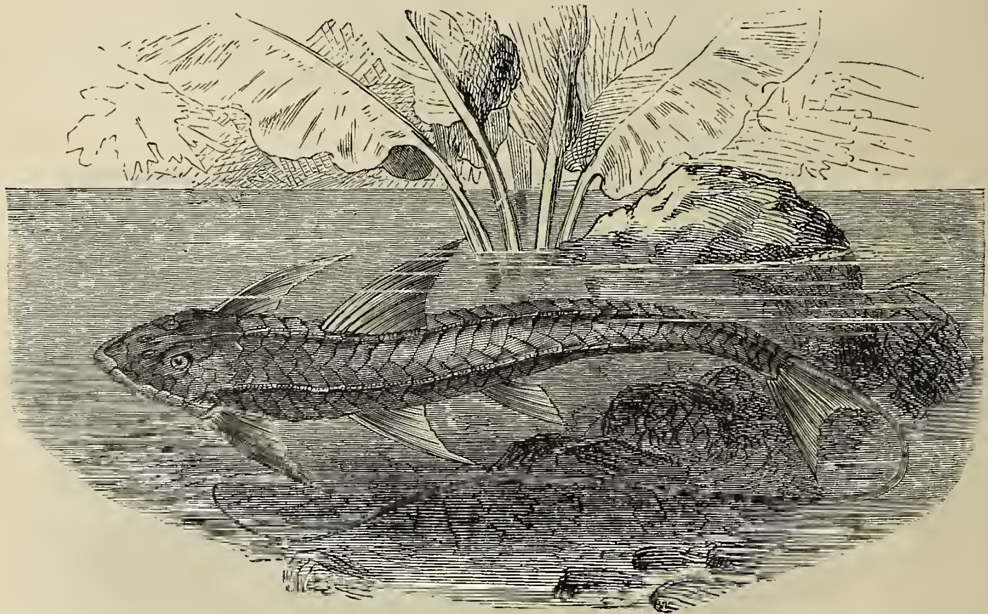
MELAPTERURUS ELECTRICUS.

nuchalis, and in the genus Doras, which has a series of about twenty lateral shields on each side of the body, each with a prominent spine in the centre. There are also broad dermal plates on the neck. All the species of the genus Doras occur in South American rivers which flow into the Atlantic. Similar lateral plates characterise the genera Oxydoras and Rhinodoras, which have a like distribution. The African genus Synodontis has broad dermal bones on the neck. The genus Rhinoglanis is a small fish an inch and a half long, from Gondokoro, on the Upper Nile, which has two dorsal fins, both formed of rays. It has six barbels, the two longest ones, from the maxillary, reach to the origin of the second dorsal fin. The whole of the neck is covered with a cuirass formed of three broad plates. The tail is forked.

The electric Siluroid, Melapterurus electricus, is found in the Nile and the rivers on the West coast of Africa. Its single dorsal fin is fatty, and placed in front of the caudal fin, which is rounded. The pectoral fins want the strong, sharp spines which are so characteristic of most fishes in this family. The body is covered with more or less small round black spots, and the anal and caudal fins are margined with white. The electric organ extends over the whole

body, and is placed below the external skin. There are two other species of this genus from Old Calabar, but neither of these possesses the electric organs. Even the electric species is dangerous to small animals only. Its flesh is eaten, and the electric organ is esteemed by the natives for its supposed healing properties, which, however, are developed by burning the tissue and allowing the patient to inhale the fumes. The next group includes genera, in which the body is more or less completely contained in bony armour. The males of the genus Callichthys have the spines in the pectoral fins stronger and longer than those of the female, the spine increasing in size as the male reaches maturity, and it is also noticed that the thoracic plates are much larger in old males than in females. The species are characteristic of the rivers of tropical America and Trinidad. Callichthys barbatus has the end of the snout armed with stiff bristles, and there are two rows of lateral shields along each side, but behind the dorsal fin the shields of the two sides join each other.

Several species of Plecostomus, another genus from tropical America, have the snout armed



LORICARIA CATAPHRACTA.

with bristles. The genus Chætostomus is remarkable for having the inter-operculum movable, and armed with a bundle of erectile spines, which are long and bristle-like. The number of spines varies in the different species, which are all from the tropical part of South America, except Chætostomus trinitatis, from Trinidad and Chæstostomus guacharote, from Porto Rico.

Similar spines characterise the Brazilian genera Pterygoplichthys and Acanthicus. The genus Loricaria, from the fresh waters of South America, has the snout more or less elongated beyond the mouth, with a short barbel at each corner of the mouth. The small bent teeth when present have the apex expanded and notched. The tail is long, and flattened, and both head and body are encased in armour. In the Loricaria cataphracta, from Surinam and Northern Brazil, the upper ray of the caudal fin is produced into an immensely long filament, a character also seen in the Loricaria vetula from the Rio de la Plata, and in several other species. There are eight or ten lateral scutcs between the pectoral and ventral fins, and the belly and thorax are defended with numerous small and irregular scutes. The outer ray of the pectoral fin is about one-sixth the length of the body. The Loricaria barbata has the sides of the head armed with erectile bristles. Most of the species have the snout broad, but in some it is long and narrow. The Loricaria acipenserina has the snout terminating in a spiny knob, and the long snout of

Loricaria depressa is turned slightly upward. Some species of this genus have been observed lying on the sand fully a yard from the water.

The genus Aspredo, the type of Dr. Günther's fourteenth group of Siluroid fishes, is chiefly remarkable for the care which the females take of their young. Dr. Günther remarks that the whole of the lower surface of the belly, throat, thorax, and a part of the pectoral fins in Aspredo batrachus, shows numerous shallow round impressions to which the ova are often found adhering. The eggs are spread out in a single layer, so as to leave small interspaces between them, which are occupied by short soft appendages to the belly, each of which expands at its free end into a disc, and these bodies help to keep the ova in position. Dr. Günther thinks it probable that towards spawning time the skin of the lower part of the body becomes spongy, and that after the eggs are deposited, the female lies on them so as to attach them to her body, and that in consequence the spongy substance is absorbed where the eggs press so as to leave the disc-like filaments of the spongy tissue in the interspaces between them. After the eggs are hatched the excrescences disappear and the belly becomes smooth. This genus has no adipose fin, and no strong spine to the short dorsal fin. The anal fin is very long. The gill-opening is a narrow foramen in front of the strong pectoral spine, which is denticulated. The species of this genus are found in British, Dutch, and French Guiana. Some species of the genus Trichomycterus ascend streams in the Andes to an elevation of fifteen thousand feet. The greater number of the South American Siluroids are small fishes.

FAMILY II.—CHARACINIDÆ.

The Characinidæ are distinguished from the Siluroids by having the head naked, and free from barbels, while the body is covered with scales. The maxillary bones form the lateral margins of the upper jaw. The air-bladder is divided transversely into two parts, and is connected with the organ of hearing by auditory ossicles. There are nearly fifty genera in this family, all of which inhabit the fresh waters of tropical Africa and America. In five of the genera allied to Macrodon there is no adipose fin, but in all the other types the adipose fin is present. Some specimens of Macrodon trahira have the tongue smooth, while others show upon it large patches of prickles. The Macrodon aimara, from Cayenne, has very large canine teeth. In the genus Erythrinus the anterior part of the hinder air-bladder has a cellular structure. All the species are from tropical America. The air-bladder presents similar characters in the Lebiasina bimaculata from Peru and Ecuador. The species of the genus Prochilodus which inhabit various parts of South America eat mud, and are remarkable for the great length of the intestine, which is coiled round many times. Great length of the intestine also characterises several other genera in this family, in which the teeth are either absent or extremely small. The nostrils vary in position a good deal in the allied genera, and are commonly more or less distant from each other, but in Tetragonopterus, a tropical American genus, they are close together, and separated only by a valve. In the genus Brycon, which is found in the east of the Andes, the pre-maxillary bone is armed with three series of teeth, which, like those in the mandible, are notched so as to have three cusps, a character also seen in the genus Chalcinopsis. The lateral line is sometimes absent and sometimes well marked in these fishes; in the Brazilian genus Gastropelecus it descends obliquely towards the origin of the anal fin. In the Anacyrtus gibbosus the two rows of teeth on the pre-maxillary bone are almost confluent into one. The Anacyrtus microlepis of Brazil has short conical processes like teeth directed outward in both the upper and lower jaws. Some genera, like Xiphostoma, have the snout elongated and conical, the prolongation being formed by a cartilaginous appendage.

FAMILY III.—HAPLOCHITONIDÆ.

This family includes two fresh-water genera, which, according to Dr. Günther, represents the Salmon. Haplochiton, from Tierra del Fuego and the Falkland Islands, has the simple air-bladder united to the thick and muscular stomach. A broad tongue carries a series of curved teeth on each side. The ovaries are in layers, and allow the eggs to fall into the cavity of the abdomen, there being no oviduct. The other genus, Prototroctes, is limited to South Australia.

FAMILY IV.—STERNOPTYCHIDÆ.

The Sternoptychidæ include six genera, four of which are naked, while the other two have the body covered with deciduous scales; both the maxillary and pre-maxillary bones bear teeth. The

genus Argyropelecus includes several deep-sea fishes from the Atlantic and Mediterranean, which have the body covered with silvery pigment, while a series of phosphorescent spots runs along the lower side of the head, body, and tail; a series of imbricated scutes extends from the humeral arch to the pubic spine. A similar series of twenty-five luminous spots marks the body of Coccia ovata; they are small pearl-coloured discs, each mounted on a black globular body. The stomach in this fish is remarkable for having two elongated branches, one of which is directed backwards, while the other runs forward. This group of fishes is represented on our own shores by the pearl-side, Maurolicus borealis, a small fish varying from an inch to two inches and a half long. Its sides have a resplendent silvery lustre, and on each side there are about forty-six or forty-seven pearly spots, placed in depressions in the skin, each margined with a narrow black ring. In front of the ventral fin, there are twenty-four spots on each side, extending backward from the head in two parallel rows placed low down on the side. There is a short single row extending in a curve between the ventral fin and the beginning of the anal fin, while from the commencement of the anal fin to the caudal fin the spots are so close together as to be almost confluent. It occurs throughout the North Atlantic, but most of the English specimens have been cast on shore at Redcar.

In the Mediterranean other species are met with, in two of which there are from twenty-three to twenty-five pairs of luminous spots on each side, which Dr Günther describes as resembling convex pearls, each resting upon a black globe-shaped body. The two genera of this family, Gonostoma and Chauliodus, which have thin deciduous scales, both have series of luminous spots running from the lower side of the head to the tail. They are represented by single species, which occur in the Mediterranean.

FAMILY V.—SCOPELIDÆ.

This family comprises many genera of fishes which frequent the open sea, or are found in deep water. They differ from each other in the length and position of the dorsal fin, the characters of the teeth, and presence or absence of scales. The Harpodon nehereus has been called the Bombay Duck. It is well known in this country as an article of food when imported dried. Its vertebræ are soft, and perforated by a channel which is occupied by the unossified remains of the notochord. It occurs in the Ganges and throughout the Indian and Chinese seas. Two genera, Scopelus and Scopelosaurus, have series of luminous spots which run down the sides of the head, body, and tail, and in the former genus a similar substance sometimes covers the front of the snout and the back of the tail. The species of Scopelus are chiefly found in the open waters of the Mediterranean and Atlantic, though Scopelus boöps, S. asper, and S. sub-asper are found in the Pacific. The species are all small, varying from one inch to ten inches in length. The genus Alepidosaurus is constituted for long compressed fishes which are without scales. They are extremely fragile, and the connection between the vertebræ is so loose, that the length of the fish is easily stretched. Alepidosaurus ferox, which inhabits the deep sea of Van Diemen's Land and of the Atlantic, is ferocious. The stomach of one specimen caught at Madeira contained a young individual of its own species, one Trachurus trachurus, twelve young Capros aper, one young Brama, and several Octopods, Crustaceans, and Ascidians. All the bones are flexible, and contain very little earthy matter. The vertebral column includes forty-two long vertebræ. Dr. Günther records that this fish has a system of abdominal ribs arranged symmetrically on both sides. They run the whole length of the median line of the abdomen to the origin of the anal fin.

FAMILY VI.—STOMIATIDÆ.

This family is a small group of fishes found only in the Atlantic, and usually in deep water. Three of the genera, Astronesthes, Echiostoma, and Stomias, have series of phosphorescent dots along the lower side of the head, body, and tail. The two first-named genera have the body naked, and Stomias is covered with delicate deciduous scales. Astronesthes niger has the body of a brownish-black colour, and has two dorsal fins, the second one being formed of fat, as is usual in this order. The other genera have but one dorsal fin, which is placed opposite to the anal fin. All these fishes have a fleshy barbel suspended from the centre of the hyoid region.

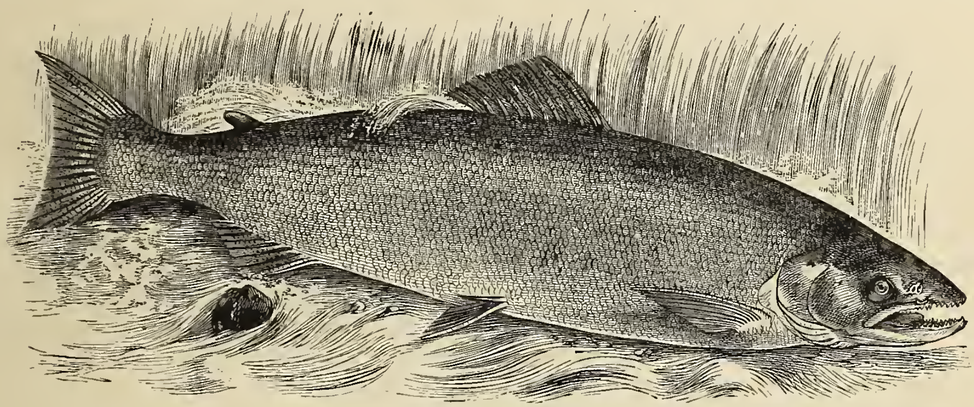
FAMILY VII.—SALMONIDÆ.

The Salmonidæ include fifteen or more genera, all of which are covered with scales, though in the Japanese Whitebait of the genus Salanx the scales are very delicate and deciduous. The head, however,

is naked in the whole family. The maxillary bones form the sides of the jaws. There is always a small fatty fin behind the dorsal fin. The air-bladder is large and simple. The eggs fall into the abdominal cavity before they are deposited. These fishes are chiefly found in the fresh waters of the temperate and arctic regions of the northern hemisphere, though the genera Argentina and Microstoma are marine, and never enter rivers; and the New Zealand Smelt (*Retropinna richardsoni*) is found only in the rivers of New Zealand.

THE SALMON.*

In the summer months the Salmon is caught in the estuaries of our rivers. Its form is too well known to need detailed description. The belly is silvery-white, as is the anal fin and the outer side of the ventral fin, the under side of which is dusky, and approaches in colour to the dusky black of the caudal, dorsal, and pectoral fins. The head in its upper part and the back are of a bluish-black colour. Often there are a few dark spots extending over the body above the lateral line, and they are commonly more numerous in the female than in the male. Low down on the back, just behind the anal fin, is a small second dorsal fin, formed chiefly of fat, and unsupported by bony rays. The first dorsal fin, in which the rays are strong, is placed about the middle of



THE SALMON.

the length of the body, nearer to the head than the tail, and the ventral fin is situate somewhat laterally below its middle or hinder part. In the mouth, teeth occur on all the maxillary bones, but in the upper jaw they also extend in the median line on the bone, called the vomer, and form an arch on the palatine bone. There are usually twelve bony rays for the support of the gills, but the number varies. The form of the operculum is one of the best characters for distinguishing the Common Salmon from the species to which it is allied, for its posterior outline is part of a circle. The scales are very small. There are 120 in the lateral line, 25 rows above it, and 18 below. There are about sixty vertebræ in the skeleton. The appendages to the commencement of the intestine, which represent the pancreas, number from sixty-three to sixty-eight. Salmon come up from the sea to spawn in rivers at various periods during the spring and summer. It has been observed that the fish are always late in going up those rivers which become muddy and swollen in the spring by the melting of snow on the mountains, but that rivers which have deposited their sediment in lakes, and thus become limpid, furnish the earliest supply of Salmon. Yarrell has drawn attention to the fact that in early spring all the Salmon which enter the river Oykel, in Sutherlandshire, diverge at about five miles from its mouth into its tributary, called the Slim, which rises in a large and deep loch, where, owing to the mass of water, the temperature is warmer; while later in the season the Salmon pass on up the main course of the Oykel, which has then become warmer.

It has also been noticed that in Cumberland the fish prefer the river Eden to the Esk, though both rivers empty into the same estuary. The Salmon ascend the river with the flood, and generally retire with the ebb of the tide. The female fishes appear before the

* *Salmo salar.*

males, and the young, on their first return from the sea, advance up the stream earlier than the old Salmon. As time goes on they ascend beyond the reach of the tide, and shoot up rapids and small cascades, often clearing a height of eight or ten feet at a bound. In Scotland they frequently kill themselves by their violent efforts to ascend streams in which there are natural obstacles. The limit of their perpendicular spring is about twelve or fourteen feet; hence ladders and staircases have been invented to enable the fish to overcome difficult rapids. When the animal has at last reached the upper and shallow pools of the river, and the spawn is deposited in the gravelly beds, the external appearance undergoes some singular changes, for in the male the lower jaw elongates and curves up over the snout, the skin thickens on the back and fins, the body acquires a golden orange tinge, and orange-coloured stripes appear on the cheeks; but the females grow darker in colour, and are spoken of as black fish, just as the males are called red fish. When spawning commences, a pair of fish working against the stream are said by some observers to make a furrow in the gravel with their noses, while others say the furrow is made with the tail. The furrow made, the male and female place themselves on each side of it. It is affirmed that they then throw themselves together on their sides, and, rubbing against each other, shed their spawn simultaneously into the furrow. This process is continued for about eight or twelve days, until all the spawn is laid, after which the fish retire to the pools to recruit their exhausted energies.

After the eggs are deposited they are covered with gravel. Eggs that were observed to be deposited in the Tweed on the 2nd of November were found on the 23rd of March to be hatching; the fry, however, less than an inch long, were lying embedded in the gravel; but a week later, Dr. Knox found that most of the young had escaped from the gravel where the eggs had lain for twenty-one weeks. Eggs laid in the autumn are generally hatched in ninety days.

The time required to hatch the Salmon is governed chiefly by the temperature of the water. The earliest experiments in hatching the fish artificially were made by Mr. Shaw, who records that the young are at first nearly transparent, with a continuous fin round the hinder part of the body, and with the yelk-bag of a bright red colour contrasting with the pale blue or peach-blossom tint of the body. His specimens measured, when hatched, five-eighths of an inch in length. When the yelk-bag has been absorbed the perpendicular lateral bars on the sides of the body make their appearance, and the fins have become thoroughly formed.

The fry of the Salmon, an inch long, have the head and eyes large, and the body of a pale-brown colour, with dusky grey bands across the sides. A portion of the ovum still hangs below the abdomen. The young Salmon of the first year has been called a pink; in the second year, until it goes down to the sea, it is a smolt; in the autumn of the second year it is a salmon peal or grilse. The young fish live on insects. Yarrell records that pinks from the river Lune were put into a small lake called Lillymere when three inches and a half long. After sixteen months they had become salmon peal fourteen inches long, and weighing fourteen ounces. Nearly a year later the length had increased by two inches, and the weight by nine ounces. Smolts are about six inches and a half long, and have the upper half of the body blue. The fish goes to sea in its migratory dress.

After going down to the sea the fish grow rapidly, and are always much larger than those which have been kept in ponds or lakes. They travel down the river in family shoals of forty, sixty, or more, moving at the rate of about two miles an hour. When the young reach any rapid current they at once turn their heads up the stream, till at last one or two bold ones allow themselves to be carried over the rapid, when the entire flock follow one by one, and keep their heads up-stream till they reach comparatively still water, when the head is once more turned to the sea, and the journey continued. The migration, according to Mr. John Shaw, continues during nearly the whole of a month. The travelling fish were six to seven inches long, and the shoals were largest and most numerous in the second week of the month. They begin to descend the rivers in March, and the descent continues through April, and part of May. They at first keep towards the sides of the river, but as strength is gained take to the mid stream. On meeting the tide the shoals rest for a day or two till accustomed to the brackish water, and then start off suddenly to the sea. Fishes which have been marked, and have gone down in April, or the beginning of May, return by the end of June, weighing from two to three pounds or more, and in July and August the weight varies from two to six pounds. These fish breed in the winter, though the eggs, in a grilse, are about as large as those of a full-grown

Salmon. A much smaller number of eggs, however, is developed. The grilse, on returning from the sea, remain for a long time in brackish water before pushing up to the tributary streams. All the fish do not return to the river from which they started, for some which have been marked have been taken in adjacent rivers. Salmon which go down from the Tweed have been caught on the Forth, and it has been suggested that when the Salmon have wandered far at sea a change in temperature may compel them to enter the nearest estuary which can be found. The Salmon at sea is a voracious feeder. Dr. Knox found in the stomach eggs of Sea Urchins, and other Echinodermata with some Crustacea. Other writers have remarked that their favourite food in the sea is the Sand Eel, with which they are easily taken. Sometimes a fish will have two or three full-sized Herrings in its stomach. They are readily captured in rivers with the common earth-worm, and by the artificial fly. The largest specimen brought to the London market of which there is record was a female weighing eighty-three pounds; and fish have been taken with the rod and line in the Tweed in former years which have weighed seventy pounds, but such weights are very unusual. At sea Salmon are sometimes caught in a net, for they swim near into shore, and ropes are stretched so as to enclose the fish and drag them towards land. Yarrell records that when the fish are seen coming up the river a boat is rowed off quickly from the fisherman's lodge with a net attached to it, which is dropped into the water and taken in a sweep, so that the fish are surrounded. Frequently dogs are trained to assist in fishing, either by driving the fish, as they would drive sheep, or by swimming across the river with lines attached to the net. Some Salmon for the English market are obtained from Norway, and the species frequents nearly all the streams which empty into the North Sea, but is not found in the Mediterranean. It does not occur farther south than the 43rd parallel of latitude, and south of the 55th parallel it becomes scarce. In Germany it occurs in the Rhine and its tributaries, in the Oder, the Vistula, the Weser, and the Elbe. It is less frequent in the west of France and the north of Spain. It is found plentifully in Russia, Scandinavia, Iceland, and Greenland. According to Brehm, the Salmon enters the Rhine in April, and has reached Basle in May. It makes its way through various small streams into several of the Swiss lakes, and reaches a height of more than 4,000 feet above the sea. In the Elbe they go up to the mountains, and reach as far as the Fichtelgebirge. The same species occur in North America.

THE GREY TROUT.*

Under the name Trout are included the Grey Trout, Salmon Trout, the Common Trout, the Great Lake Trout, and the Loch Leven Trout of our own country. The Grey Trout is easily distinguished by the remarkable squareness of the outline of its operculum, which is relatively larger than in the Salmon; its teeth too are longer and stronger than in Salmon, and the outline of the tail, owing to the growth of the central caudal rays, becomes convex in the older fish. It is met with in many of our rivers, and Yarrell quotes it from the rivers of South Wales, Cornwall, Dorsetshire, the Cumberland streams which run into the Solway Firth, and it occurs all round the northern shores of Ireland. Dr. Günther regards the Lake Trout of the Orkneys, which does not migrate, as a distinct species. It usually weighs less than fifteen pounds, but sometimes reaches a weight of twenty pounds; the flesh is paler than that of the Salmon, and it is less valued for food. Lord Home mentions that the Bull Trout, as this species is sometimes called, comes up the Tweed first at the end of April or beginning of May, when the fish weigh from two to five pounds. Towards the end of November, however, they come up in thousands, and then weigh from six to twenty pounds. The length of the head to that of the body is as one to four. The lower jaw of the male elongates, though to a less extent than in the Salmon. The dorsal fin commences exactly half way between the extremity of the nose and the origin of the outermost rays of the tail. The scales are rather smaller than those of the Salmon; between the lateral line and dorsal fin there are twenty-six, while below the lateral line there are about twenty-five rows. The anal fin is nearer the tail than in the Salmon. Usually there are fifty-nine vertebræ, or one fewer than in the Salmon. The shoulders are thicker than in the Salmon, and the bases of the fins and fleshy part of the tail are stronger. In the spawning season the head of the male becomes olive-brown, and the body orange-brown, while the females are blackish-grey.

* *Salmo cambricus.*

The SALMON TROUT (*Salmo trutta*) has the gill-cover, or operculum, intermediate in form between that of the Salmon and the Grey Trout. The teeth are more numerous and more slender than in either of these fishes; those on the vomer extend almost throughout its length; the tail is relatively smaller and shorter than in the Salmon. The body is rather deep in proportion to its length; the scales are a longer oval than those of the Salmon; there are twenty-nine above the lateral line and twenty-two below it. Compared with those of the Salmon, the fins are of lighter colour and the body darker. The spots are somewhat cross-shaped and chiefly above the lateral line. The cheeks and gill-covers are silver-white, and the pectoral fin is bluish-white. This species especially abounds in Scotland, and is valued as inferior only to the Salmon. It is caught in Ireland, Wales, the Severn, and the South, West, and North of England. Sir William Jardine mentions that this species enters every river and rivulet along the Scottish coast in immense numbers, feeding on flies, beetles, and other insects, especially the sand-hopper. Two hundred are frequently taken at a single draught of a sweep net. Lord Home states that he never saw one in the Tweed weighing more than seven pounds.

The COMMON TROUT (*Salmo fario*) is found in most of the rivers and lakes of Great Britain. In battle a Trout vanquishes a Pike, and the fish is especially remarkable for caution, vigilance, and valour. The Trout usually spawns in the month of October. The eggs and milt appear to retain their vitality after the fishes are dead, for the ova have been fecundated artificially when the fishes have been dead for three days. The usual number of vertebræ in the Common Trout is fifty-six. The largest caught in the Tweed by Lord Home weighed five pounds, but in the Leet specimens were killed weighing seven pounds. He remarks that the nature of the soil through which the stream flows exercises considerable influence on the colour, size, and quality of the fish. In the rivers Eden and Leet the bodies are marked with bright red spots, fins and sides orange-coloured, the flesh a deeper red than that of the Salmon, and is almost as full flavoured. The food of these fish consists of small molluscs, caddis-flies, and other flies abounding where the banks of rivers are calcareous. They feed towards evening. The spots and colours are generally most brilliant where the bottom is gravelly. The fish is finest in flavour from the end of May to the end of September. In the second year the Trout are said to associate with the Minnows, and in the third year, when they appear in the shallows, are about seven or eight inches long. When well fed, they increase from one to ten pounds in four years. A Trout was taken from a branch of the Avon at Salisbury which weighed twenty-five pounds. Trout have often been kept alive for long periods in wells, and at Broughton-in-Furness one is recorded to have lived in a well for fifty-three years. It occurs in several of the Irish loughs, where the bottom is more or less rocky, and it is said to have been caught in Lough Neagh forty inches long, and weighing thirty pounds. This species presents two well-marked varieties, one found in Scandinavia, Iceland, and Scotland, and the other in England, France, Central Europe, Russia, and the Maritime Alps.

The GREAT LAKE TROUT (*Salmo ferox*) is found in most of the larger and deeper lochs of Scotland and Ireland. It seldom ventures up or down streams, and never descends to the sea. It feeds almost entirely on smaller fishes, and is generally taken on trolling lines baited with a small Trout. The flavour is coarse, and the flesh has an orange-yellow colour. Fine specimens from Ulleswater are said to weigh between fifty and sixty pounds. When full grown and in season it is purplish-brown above, changing through reddish-grey into orange-yellow on the breast and belly. When newly caught, the fish appears as though glazed over with a tint of lake colour, which disappears as it dies. The gill-covers are marked with large dark spots, and the body is covered with markings; the fins and lower part of the body have a rich yellowish-green colour, which becomes darker towards the ends; the tail is more than usually broad and powerful. The scales are more circular than those of the migratory species of Trout. This species is met with in the great lakes of Scandinavia. There is one ray less in the dorsal fin than in that of the Common Trout.

The most southern Trout of the whole world is the Salmo macrostigma, from Algeria, which reaches a length of six or seven inches. It is covered with 122 tranverse series of scales. Trout occur in Spain, but the species have not been accurately determined. There are two or three species in the rivers of Dalmatia. The Great Dalmatian Trout (*Salmo dentex*) reaches a length of forty-four inches. The Salmo obtusirostris, rarely more than a foot long, is also found in the Tiber. The Lake of Garda contains the Salmo carpio; the Lake of Geneva the Salmo lemanus, and this species is also

THE COMMON TROUT.

found in the Lago Maggiore. It has a green back and silvery sides and belly, with small cross-shaped black spots on the sides. The Salmo rappii and Salmo lacustris are both found in Lake Constance, the latter ranging into the lakes of Upper Austria. The former is rather the larger species, but both reach a length from two feet six to three feet. The Salmo marsilii of the mountain lakes of Upper Austria is remarkable for having from ninety to a hundred pyloric appendages to the stomach, about twice as many as are usually found in Trout. This species reaches a length of three feet. Salmo microlepis is found only in the rivers of Hungary. In France, the rivers running into the Atlantic yield the Salmo argenteus, which reaches a length of two feet and a half. There are several Trout peculiar to Scandinavia and Finland, others are found in the Crimea, in Armenia, the rivers of Hindu Koosh, and the Pacific coast of Northern Asia and North America, especially British Columbia, while to the east of the Rocky Mountains other species, which do not migrate, are found in the great lakes.

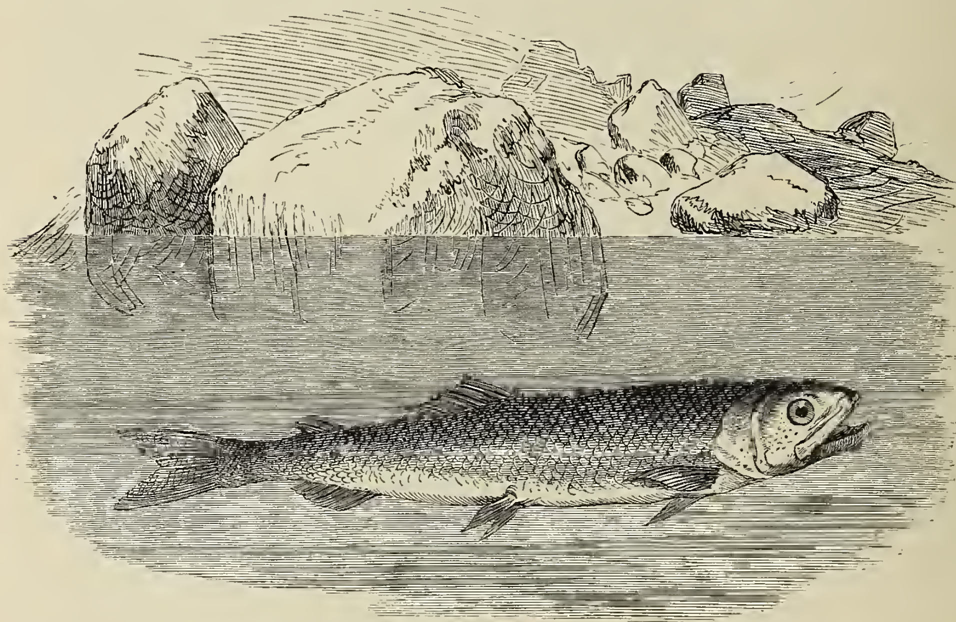
The CHARR (*Salmo alpinus*) is remarkable for the smallness of its scales. In the breeding season the belly acquires a bright red or orange tint, and they are hence called Rothfohren by the Swedes. They are found throughout the lakes of Switzerland, Germany, the British Isles, and Scandinavia. In form they vary with the locality. Mr. Thompson states that in some lakes they are nearly as round as an Eel, while in others they approximate to the form of a Herring. In Windermere they generally weigh from half a pound to a pound or more. Formerly the Charr occurred in Lake Llanberis, but the waters from a copper mine drove it down to the sea, where it still continued to be caught at the mouths of rivers on the coast. The Charr generally live in the deepest parts of the lakes. The stomach is commonly empty, though it sometimes contains small fresh-water Crustacea. The spawning season is in November and December, when the fish make their way into the stream which runs into the lake, though the spawn may be deposited in the lake itself where the bottom happens to be stony. This species is in the greatest perfection for food between July and October. The Charrs have been separated from the Salmon as a sub-generic group called Salvelini, characterised by having teeth only on the head of the vomerine bone, while all the true Salmon have teeth not only on the head of the bone, but along its length. Most of the Charrs have teeth in the median line of the hyoid bone. They are a large group, comprising about thirty species.

Among the European species are the Ombre Chevalier (*Salmo umbla*), which is limited to the Lakes of Constance, Neufchâtel, and Geneva; the Salmo salvelinus, which is not clearly distinguished from Salmo umbla. It is characteristic of the alpine lakes of Bavaria and Austria, but also occurs in Sweden. Salmo nivalis is a Charr from the lakes and rivers of Iceland, which reaches a length of twenty-one inches. The Windermere Charr (*Salmo willughbii*) is also found in some of the lochs of Scotland; Salmo killinensis is known only from Inverness-shire, and grows to a length of ten to fifteen inches. Salmo perisii is found in the lakes of North Wales. Salmo grayi is the Fresh-water Herring from Lough Melvin, in Ireland. Another Irish species, seven or eight inches long, has been named Salmo colii. The Salmon of the Danube, which when old attains a reddish tinge, is named Salmo hucho, and is characterised by wanting the median teeth on the hyoid bone. Another species, Salmo lossos, frequents the rivers flowing into the Baltic, and has been found in the river Kama, as well as in the Caspian Sea. There are several Asiatic species of this group, such as the Salmo fluviatilis, which does not appear to be migratory, and sometimes reaches a weight of eighty pounds in the Siberian rivers. Salmo erythrinus is a Charr from the mountain lake Frelicha, which communicates with the north-east of Lake Baikal; and there are other species in the rivers which make their way into the Pacific. Two species of Charr are recorded from the fresh waters of the Pacific side of North America, and several others from the lakes and rivers of the eastern side of that continent. Salmo hudsonicus is found in Hudson's Bay, Labrador, and Newfoundland. Other species have been found in the highest northern latitudes.

The genus Oncorhynchus includes several species of migratory fishes, with an elongated anal fin, having more rays than the Salmon found in the American and Asiatic rivers which flow into the Pacific. The Californian Salmon belongs to this genus. The Oncorhynchus sanguinolentus, which often weighs from ten to twelve pounds, acquires a blood-red colour on the sides in October, but the colour fades to a brick-red tint in January. Its eggs are large.

The next important genus in this family is Osmerus, of which there are three well-known species: Osmerus thaleichthys, common in the Bay of San Francisco, can be burned like a candle;

Osmerus viridescens, occurring on the Atlantic coast of the United States; and the Smelt (*Osmerus eperlanus*), which is common on the coasts and in the fresh waters of Northern and Central Europe. It is plentifully taken on the rivers of the east coast of England and Scotland, and is termed Smelt by the Danes. It is found in fresh water only from August to May. After depositing its small yellow eggs it returns to the sea. The eggs, unlike those of the Salmon, are not covered over. The Smelt is remarkable for its cucumber-like odour, which becomes less powerful when the fish has been some time out of water. It is one of the most delicate and exquisitely flavoured fish brought to table. Yarrell mentions that they have been kept for several years in ponds having no communication with the sea, and had in no way deteriorated in size or flavour. Occasionally specimens have been caught thirteen inches long, but the usual size is about seven inches. The back is of a transparent greenish tinge, and the sides are silvery. The scales are small, oval, and deciduous. The lower jaw is longer than the upper jaw.



THE SMELT.

The largest teeth are on the vomer and fore part of the tongue: there is a double series of teeth on the mandible. There are usually about sixty vertebræ and very few pyloric appendages to the stomach.

The Capelin (*Mallotus villosus*) is one of the smallest of the Salmonidæ, found on the shores of Kamtschatka and Arctic North America. It lives on the sea-bottom, and comes to the surface to spawn, when it often congregates in incredible numbers. It is eaten fresh in Iceland, and dried in Greenland. It furnishes one of the most important baits for the Newfoundland fisheries.

Coregonus is a genus of fishes found in the fresh waters of the north temperate regions of the Northern hemisphere, but many species periodically move into the Arctic Ocean. Dr. Günther states that they are less variable than the Trout, and all the species are characterised by having the body covered with medium-sized scales, by a deeply forked caudal fin, a large air bladder, and a horseshoe-shaped stomach, to which there are numerous pyloric appendages. The Coregonus oxyrhynchus, well known on the coast and in the fresh waters of Holland, Germany, Denmark, and Sweden, has the snout produced in the upper jaw into a fleshy conical process. The snout is also somewhat prolonged in the Swedish species Coregonus lloydii, where, however, it is much thicker.

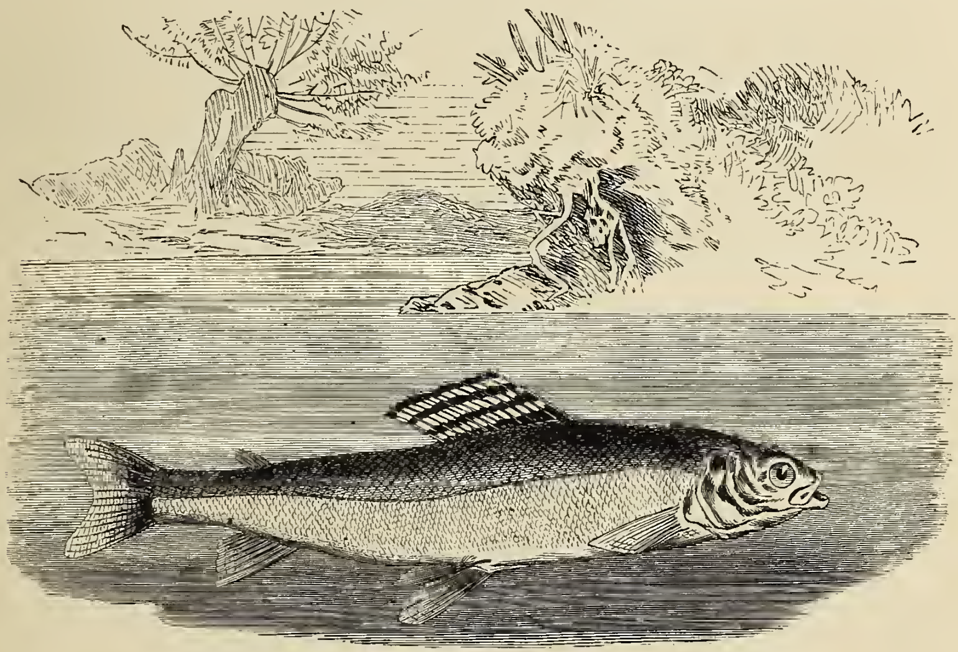
Coregonus quadrilateralis has the profile of the snout remarkably rounded, and has the eye very large. It reaches a length of eighteen inches, and is characteristic of the northern parts of North America. Several species have the snout obliquely truncated; among these are the Coregonus lapponicus, from Lapland, and the Coregonus lavaretus, which is found in the great lakes of

Switzerland, the Tyrol, Prussia, and Sweden. Fine specimens reach a length of two feet. There are several other species found in the lakes of Central Europe and Sweden, but all have the same truncation of the snout; other species are confined to the Siberian rivers; several are found only in Lake Superior and other lakes of Northern and Arctic America.

Another group of species has the snout vertically truncated, and of these the Coregonus clupeoides is known only from the lakes of Great Britain. It grows occasionally to a length of sixteen inches, and feeds on minute fresh-water crustacea, larvæ of insects, water-beetles, and small red worms. In Loch Lomond, where they are plentiful, and caught with the drag net, they are known as Fresh-water Herrings, or Powans. They are greatly valued for food, and are in the best condition in August and September. The Coregonus albula, which is found in the north of Europe, has the lower jaw longer than the skull. Another British species, found in Dumfriesshire, is known as the Vendace (*Coregonus vandesius*). It has the dorsal and ventral fins long, and the tail deeply forked. These fish swim in great shoals, and retire into deep water in warm weather. They congregate in great numbers at spawning time, which is about the beginning of November. They resemble the Smelt in flavour. The females are about eight inches long, while the males are about an inch shorter. The colour of the back is brown, and the sides are tinged with yellow.

The Pollan (*Coregonus pollan*) is an Irish species of this genus, remarkable for the shortness of the head and depth of the body. It has the aspect of a fresh-water Herring, and, like the Herring, is gregarious. It reaches a length of ten or eleven inches. Coregonus lucidus, from Great Bear Lake, is known as the Herring Salmon; Coregonus clupeiformis, found in Lakes Erie and Ontario, is locally known as the Fresh-water Herring, and sometimes as the Shad Salmon.

The Grayling (*Thymallus vulgaris*) is found in the fresh waters of Central and Northern Europe, and is well known in various parts of England and Wales. Large specimens may weigh from four to



THE GRAYLING.

five pounds. It is in the best condition in October and November, flourishes best in rivers with a rocky or clear bottom, and is unable to exist for long in muddy ponds. It feeds on various flies, which are imitated by anglers, and eats the smaller fresh-water mollusca, such as Neritinæ and Physæ. When freshly taken from the water it has an odour like thyme. It reaches a length of ten inches. It is marked on the sides with dusty longitudinal bars; the general colour is a yellowish-brown, but the scales reflect many colours in different lights. Towards spawning time the pectoral fins become

reddish. The dorsal fin is elevated with more rays than species of Coregonus, is of a violet colour, with purple spots, and the trunk is marked with a few small round black dots.

The Argentina hebridica is a member of another genus, which, while entering fresh waters, is also found in the European seas at great depths. It somewhat resembles a Smelt in form, size, and odour, but is covered with rather large scales. Species of this genus have been dredged from a depth of over 2,000 fathoms in Arctic and Antarctic waters.

FAMILY VIII.—PERCOPSIDÆ.

The Percopsidæ, represented by Percopsis guttatis, are characterised by having the body covered with ctenoid scales. The species is found in Lake Superior.

FAMILY IX.—GALAXIDÆ.

The Galaxidæ include two genera of fresh-water fishes, which all have the body naked, and have hook-like teeth on the tongue, and conical teeth in the jaws and on the palatine bone. The species occur in Australia, New Zealand, and the southern part of South America. They vary from two inches to about seven or eight inches in length. The genus Galaxias has only been found burrowing in clay, at some distance from water.

FAMILY X.—MORMYRIDÆ.

This family comprises three genera of fishes from tropical Africa. The pre-maxillary bones unite into a single bone; the inter-operculum is sometimes rudimentary. All the fins are well developed, but there is no adipose fin. A series of pores extends along the base of the dorsal and anal fins. The genera are distinguished by the presence or absence of teeth on the tongue, and the species are defined by the form of the dorsal fin, length of the snout, and the size of the scales. Most of the species of Mormyrus are found in the Nile, where the other genera, Mormyrops and Hyperopisus, also occur.

FAMILY XI.—GYMNARCHIDÆ.

The Gymnarchidæ are known only from the Gymnarchus niloticus, found in the Nile and rivers of West Africa. It reaches a length of six feet, has an eel-like body, and is chiefly remarkable for the cellular character of the air-bladder, which is capable of being distended. As in the preceding family, the upper jaw is formed of both the maxillary and pre-maxillary bones, and there is similarly a cavity extending into the interior of the skull on each side of the parietal bone, but covered with a thin bony plate. Another point of resemblance is a series of pores along the base of the dorsal fin. In this fish, however, the anal and ventral fins are absent. The tail tapers, and has no caudal fin. It resembles Mormyrus in having an imperfectly developed electric organ on the tail, with the usual prismatic structure, but without electric functions.

FAMILY XII.—ESOCIDÆ.

This family comprises the Pikes, which all belong to the genus Esox, and occur in the fresh waters of the temperate parts of the northern hemisphere. Several species of this genus are limited to North America; but the European Pike (*Esox lucius*) also occurs in the northern parts of North America, as well as in Northern Asia.

THE PIKE.*

The Pike (*see* figure on p. 1), when full grown, may reach a length of five or six feet. In Loch Lomond, examples have occasionally been taken weighing about eighty pounds; one is recorded from the Shannon that weighed ninety-two pounds. The fish is certainly long-lived, and Gesner refers to an example, said to have been nineteen feet long, which weighed 350 pounds. In the middle ages rings were sometimes put in the gill-covers of fishes; and on evidence of this kind it has been supposed that Pike have sometimes lived for more than 250 years. The young are said in the first year to grow to a length of eight or ten inches; in the second year they increase to twelve or fourteen inches; and in the third year the length is eighteen or twenty inches; after which the weight and size augment in proportion to the supply of food, for the Pike digests rapidly, and therefore, stimulated by hunger, is bold and active in the pursuit of prey. The stories of its voracity are almost inexhaustible. In one case a Pike swallowed the head of a swan; in another case this fish seized on the lips of a mule that had gone down to the Rhone to drink. It is said sometimes to fight with the otter for possession of fish. The instances are many of Pike seizing the hands and feet of bathers. An early writer, Dr. Crull, quoted by Couch, states that a Pike had been captured

* *Esox lucius.*

with an infant child in its stomach. Ducks, geese, and water hens are all sometimes found in the stomachs of these fish. Instances have been known of a Pike swallowing one of its own species scarcely smaller than itself, but then the devoured fish can only be taken into the body of the devourer gradually, as digestion progresses. The more ordinary food of the Pike, however, is furnished by frogs and small fishes. According to Mr. Jesse, eight Pike, of about five pounds' weight each, consumed 800 Gudgeons in three weeks. They readily take Roach and Carp, Tench, and probably most fresh-water fishes, though they are believed to avoid Perch and Sticklebacks.

The Pike is supposed to first spawn when it is three years old. The spawning season lasts for about three months, but the ova are usually deposited in March. A single Pike, weighing thirty-five pounds, may contain more than 270,000 eggs. The young are hatched in about a month, but comparatively few reach maturity. The Pike is well known to travel over land, and annual migrations of the fish have been recorded. They come in the spring in great shoals out of the Isle of Ely into the river Cam. In the earlier times of history, the Pike appears to have been rare in this country, though the occurrence of its bones in the peat of the fens may be taken as evidence that it is a native fish and has not been artificially introduced. In former times Pike were held in greater favour as food than now, and they were fattened by being kept in cages in the river Cam, often selling for large prices. The Pike is said to be at its best when it has preyed upon the Smelt. In Lapland, it is dried for winter use. The old families of Lucie, of Cockermouth, and Egremont, have on their arms three silver pikes on a red field. The Pike has a long and somewhat compressed body, with a rounded back, the snout is depressed, broad and long, but not so long as the lower jaw. The body is covered with small cycloid scales; the lateral line is not well marked. There are no barbels; the dorsal fin is placed far back on the tail, and is opposite to the anal fin. The caudal fin is broad and forked. The teeth in the mandible form a single series, and vary in size. Teeth also occur in bands on the pre-maxillary bones, vomer, palatine bones, and hyoid, but there are no teeth on the maxillary bones. There are no scales on the sub-operculum and lower part of the opercular bone. The pseudo-branchia, or gills on the operculum supplied with arterial blood which is afterwards conveyed to the eye, have a glandular character, and are covered by the mucus membrane which lines the gill cavity. There are no pyloric appendages to the stomach; the air-bladder is simple. The colour of the head and back is olive-brown, the sides become paler, and the belly is silvery white; the body is mottled over with more or less round spots, which sometimes form cross-bars on the tail. The dorsal, anal, and caudal fins are generally spotted with brown. The Pike often sleeps or remains in an unconscious state, in quiet parts of rivers; when thus dozing it may be taken with a kind of noose.

FAMILY XIII.—UMBRIDÆ.

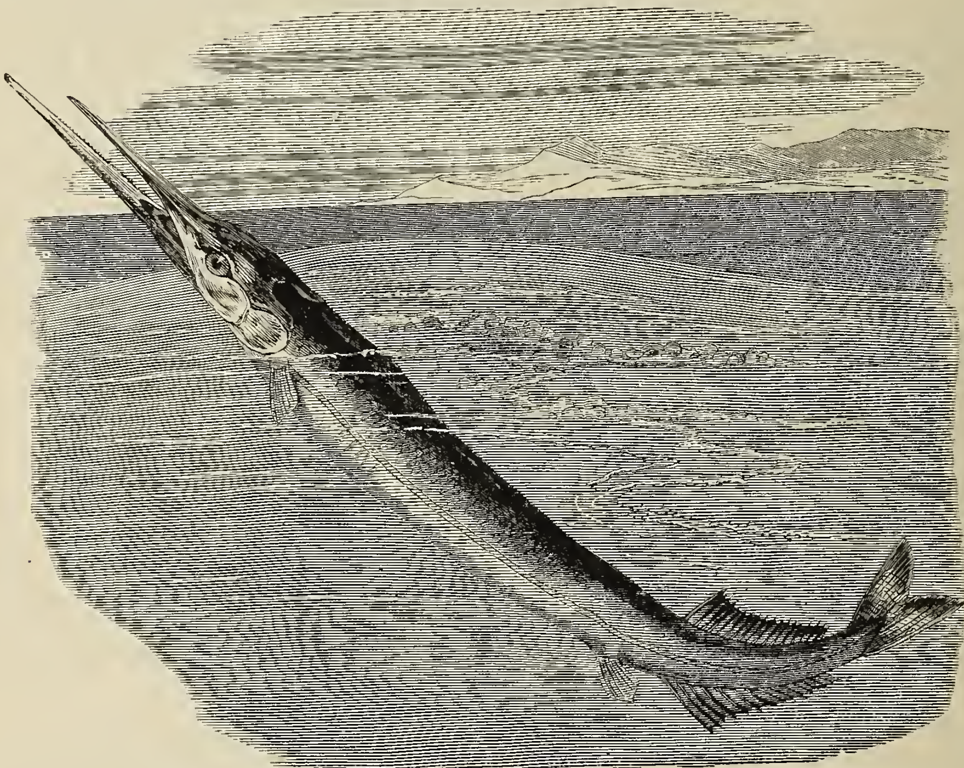
The Umbridæ are known only from the genus Umbra. Umbra krameri is a small fish three or four inches long, which is found in stagnant water in Austria and Hungary, and has occurred in the neighbourhood of Odessa. The Umbra limi from the fresh waters of the United States is rather smaller. The dorsal fin in these fishes is rather long, the ventral fins are below its commencement, and the small anal fin is below its termination. The caudal fin is rounded. The head is broad and blunt, with short jaws armed with small slender teeth.

FAMILY XIV.—SCOMBRESOCIDÆ.

This family comprises genera which are characterised by having a series of keeled scales along each side of the belly. The dorsal fin is opposite the anal fin, and both are placed in the caudal region of the body. The lower pharyngeal bones are united together. The intestine is quite straight, without a distinct stomach. The air-bladder, which is large, is sometimes cellular, but has no pneumatic duct; it is occasionally absent.

The genus Belone is well known, from a multitude of species which chiefly frequent tropical waters, but are widely distributed. Many species are found in the West Indies and adjacent coasts of Brazil, and one (Belone tæniata), which has the rays of the dorsal fin all of about the same length, is found in the river Capin, in Brazil. Other forms, like Belone euxini, are limited to the Black Sea; several, such as Belone acus, are found only in the Mediterranean. One species frequents the coast of Portugal, and the Common Garfish (*Belone*

vulgaris) ranges round the Northern shores of Europe. The species extend down both the Atlantic coast of Africa and the Red Sea, abound in the Indian and Chinese Seas and Indian Archipelago, reaching to Australia on the one hand, and by way of the Sandwich Islands to the Californian coast, on the other. This genus is characterised by a slender, elongated body, which has the jaws prolonged into a slender beak; but in the young the jaws are short, and the pre-maxillary bones, like the lower jaw, become lengthened as the fish reaches maturity. Both jaws are armed with bands of minute teeth, and larger conical teeth, which are widely separated, though certain species have no teeth on the palate. Among such may be mentioned the Belone canciloides, from the rivers of Borneo.



THE GARFISH.

The Garfish (*Belone vulgaris*) is often taken with the Mackerel, in advance of which it usually swims. It is plentiful all along the English Channel in spring, and occurs on most parts of the British coasts. The majority of the fish retire in the winter into deep water. The species is extremely active, swims near to the surface, and takes the bait readily. Couch records that it often feeds on a black fly, which alights on the sea in fine weather, the stomach being sometimes filled with it. It also feeds on the Herring, but the stomach is only large enough to hold one at a time. It is largely used for bait. When newly-caught it has a disagreeable odour; the flesh has much the flavour of Mackerel, but is drier. Full-grown specimens vary from two feet to two feet six inches in length, but the body is only one inch and a half deep. The head and back are of a dark bluish-green tint, becoming paler at the sides, and brilliant white on the belly. The ventral fin is about midway between the operculum and the tail; the dorsal and anal fins are similar to each other, and near to the caudal fin. The caudal fin is forked. The body is covered with small scales, which are very thin. The upper jaw, as in many birds, has a jointed union with the skull. The bones of the Garfish are green.

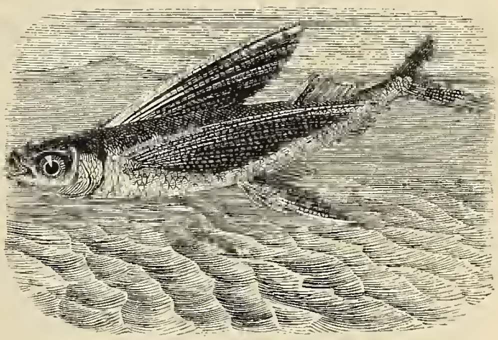
The genus Scombresox has a close general resemblance in form of body to Belone, the jaws being similarly elongated, and the body similarly slender, and covered with thin deciduous scales. The essential difference between the genera consists in the development in Scombresox of a number of detached finlets posterior to the dorsal and anal fins, which extend to the caudal fin. In this genus, too, the lower jaw is longer than the upper. Several species are known from New Zealand, Japan, Chili, the Mediterranean, and both sides of the Atlantic. The last species referred to—Scombresox saurus—commonly known as the Saury, or Skipper, is usually from a foot to eighteen inches long, and the depth of the body may be about an inch. The teeth are small; the upper jaw has a hinge movement, as in Belone. The food of this fish consists chiefly of the smaller crustacea, though the stomach occasionally contains sea-weeds. Like the allied Belone, it resembles the Mackerel in flavour, and swims on the surface. It travels in shoals, and has the power, when followed by the Porpoise, or carnivorous fishes, of springing out of the water to a height of several feet, and passing over a distance of thirty or forty feet before it again touches the sea. Couch, indeed, mentions that, when pursued, the fish rush along the surface, like pebbles making "ducks and drakes," for more than a hundred feet, apparently by the repeated touch on the water of the pectoral, ventral, and other fins and finlets on the lower part of the body. Several thousands have sometimes been taken in a single cast of the seine net.

The third genus—Hemirhamphus—includes about forty species, mostly from tropical seas, though they are perhaps more abundant in the East Indian Archipelago, and adjacent waters, than elsewhere, and certain species, like Hemirhamphus fluviatilis, occur only in the rivers of Java and other Eastern countries. Hemirhamphus is remarkable for having the lower jaw prolonged into a slender, compressed beak, while the upper jaw is short. Both jaws are armed with minute teeth, which in some species are tricuspid. The body in these fishes is elongated and slender, and covered with scales, which are never small. It is worthy of notice that the lower jaw is short in young specimens. The young of Belone have been mistaken for Hemirhamphus, even by Yarrell and Couch. The species are mostly small, and range from a length of two inches to a foot. The Hemirhamphus cuspidatus, from the Indian Ocean, has the prominent part of the lower jaw remarkably short, and the pectoral fin about a quarter of the total length of the animal.

Arrhamphus sclerolepis, from the coast of Queensland, is the only species of its genus, and differs from Hemirhamphus in the shortness of the lower jaw. The scales are keeled.

FLYING FISH OF THE GENUS EXOCOETUS

This genus includes a large number of species, which all have the pectoral fins very long, and capable of being used to support the fish when moving through the air. In some species the length is more than half that of the body; in other species it is somewhat less. These fishes, which abound in the seas between the Tropics, and frequent the open ocean, are widely distributed, and often extend north and south into temperate waters. Many species are very small, and do not exceed a length of two to three inches, and none are large, though the Exocoetus lineatus, from Madeira, and some other species reach a length of sixteen inches. Certain types have barbels below the mandible. The jaws in these fishes are short, and the teeth are minute, or may be wanting altogether. The oblong body is covered with large scales. The best-known of the Flying Fishes is the Exocoetus evolans, which ranges from Australia and the China Seas over the Indian Ocean, and is met with in the West Indies, Mediterranean, and sometimes on the coast of England, shoals having been seen off Portland and in many other localities. The snout is blunt, something like that of the Grey Mullet; the body is wide across the back, compressed at the sides,


THE EXOCOETUS VOLITANS.

and becomes smaller towards the tail. The pectoral fins extend backward as far as the root of the caudal fin, and the ventral fin is placed in advance of the dorsal fin, which is on the hinder part of the body. The pectoral fins are black, with the lower border whitish, and the ventral fins are white. The caudal fin is unevenly forked. The usual length of this species is about sixteen inches, though Couch refers to an example which was twenty inches long. The body is dark on the back, has a bluish tinge on the sides, and is white below. The longest time for which these fish have been seen to sustain themselves out of the water is thirty seconds. There is no visible movement of the pectoral fins during this time, and it is probable that the impetus is given to the fish by its tail while still in the water. The longest flight observed has exceeded two hundred yards. The usual height of the fish above the surface of the water when thus flying is from two to three feet; but they have been known to come on to ships of war at a height of more than twenty feet above the sea. They are stated never to raise themselves above the height which they first reach. Thousands often rise out of the sea at once, and move in many directions. When kept in vessels of sea-water they can rise out of it to a height of only a few inches. In all these fishes the air-bladder is large, and Humboldt mentions that in a fish sixteen centimetres long the air-bladder has a length of nine and a breadth of two and a half centimetres. The stomach has been found to contain small fishes, crustacea, and many small marine animals. The Exocoetus volitans is limited to the Mediterranean. This species belongs to the group with long ventral fins. The Flying Fish have many enemies. Prominent among these are the Bonito, Tunny, Porpoises, and sea birds; and they are good eating.

FAMILY XV.—CYPRINODONTIDÆ.

This family comprises an assemblage of about twenty genera of small fishes, which are mostly viviparous, and found in the fresh waters of Southern Europe, Africa, Asia, and America. The family is subdivided into two principal groups. The first of these, called Cyprinodontidæ carnivoræ, has the bones of each mandible firmly united, and the intestine short, or but slightly convoluted. In the second group, Cyprinodontidæ limnophagæ, the dentary bone is movable upon the other bones of the mandible; the intestine has many convolutions, and, as with some of the genera of the other group, the sexes present distinct external characters. Cyprinodon has several species, confined to the fresh and brackish waters of the Mediterranean region. Cyprinodon calaritanus occurs in the South of Europe, and in the hot springs of the Sahara. The males are of an olive colour, with nine or ten narrow silvery crossbars, but the females are silvery on the sides, with black vertical stripes which do not extend on to either the back or the belly. Cyprinodon dispar is found in Abyssinia, and also in the Dead Sea. Cyprinodon cypris is from the river Jordan and Bagdad. The New World species are from Long Island, Texas, and other parts of the United States. The species range from an inch to a length of about five inches. The genus Fitzroyia has tricuspid teeth like those of Cyprinodon, but instead of being arranged in a single series, as in that genus, they form several series. The species F. multidentata is from Monte Video. The single species of Characodon, from Central America, has the small teeth bicuspid. The Tellia apoda, from the higher pools of the Atlas Mountains, differs from Cyprinodon chiefly in wanting the ventral fins. Haplochilus has slender, viliform teeth in both jaws. The species belong to the Indian region, to tropical Africa, and temperate and tropical America. The genus Fundulus, like the preceding genus, has the upper jaw movable, and capable of being protracted. The species are all small and insectivorous. Fundulus hispanicus lives in the fresh waters of Spain. The known species of the genus Orestias, in which the ventral fins are absent, are all from Lake Titicaca. In Jenynsia the teeth are notched, and the anal fin of the adult male is modified into a conical remarkable organ, in which scarcely any of the rays remain distinct, a character found in several allied genera. Anableps has the arches above the eyes greatly elevated, and the eye itself is divided by a dark-coloured transverse band into upper and lower portions. This is not merely an external character, but the pupil itself is completely divided into two, by lobes of the iris which project from the front and back margins of the eye. The anal fin of this fish is modified in the male into a thick and long conical organ covered with scales, and is perforated at

the extremity. The species of Anableps are from the fresh waters of Central America and the Guianas. The second group of this family includes four or five genera of mud-eating fishes. The species are all from the West Indian Islands and Central and South America. The more important genera are Poecilia, in which the minute teeth are arranged in bands, and Girardinus, in which the pointed teeth are arranged in a single series, and the origin of the anal fin is in advance of that of the dorsal fin. All these fishes are small.

FAMILY XVI.—HETEROPYGII.

This family is formed for two genera of North American fishes, which have the heads naked and the body covered with minute scales. The dorsal fin is opposite the caudal fin, and both are placed on the caudal region of the body. Amblyopsis spelæus is a viviparous fish found in the caves of Kentucky, which has the eyes absent or rudimentary, the lower jaw rather larger than the upper, a band of teeth on each palatine bone, and the head covered with vertical wrinkles, which constitute an acute organ of touch. The sense of hearing is also well developed. It is colourless, and has the ventral fins rudimentary, and sometimes entirely absent. It reaches a length of five inches. It is found in the Mammoth Cave of Kentucky. Chologaster cornutus is a similar fish, found in ditches in the rice-fields of South Carolina, but differs from the foregoing in possessing eyes. The specific name is derived from the circumstance that the snout is provided with two horn-like processes.

FAMILY XVII.—CYPRINIDÆ.

This vast family comprises more than a hundred genera of fresh-water fishes, and includes the majority of the species from the fresh waters of Europe and Asia, and is well represented in Africa and North America. In our own country the group is known from such familiar examples as the Carp, Barbel, Tench, Gudgeon, Gold-fish, Bream, Chub, Roach, Dace, and Minnow. In this group the head is naked, and the body generally covered with scales. As a rule the belly is rounded, the mouth is toothless, and the upper jaw is formed by the pre-maxillary bones. The lower pharyngeal bones are furnished with teeth, which may be arranged in one, two, or three rows. The stomach has no pyloric appendages. The air-bladder is usually large, though its modifications furnish characters for three primary divisions of the family. Dr. Günther regards the Cyprinidæ as including fourteen groups. In the first twelve of these the air-bladder is divided transversely into anterior and posterior portions; and there are never more than four barbels.

In the second division, which comprises the Homalopterina, the air-bladder is wanting. In the third division the air-bladder is more or less completely enclosed in a bony sheath. This group is known from its typical genus as the Cobitidina; the barbels vary from six to twelve.

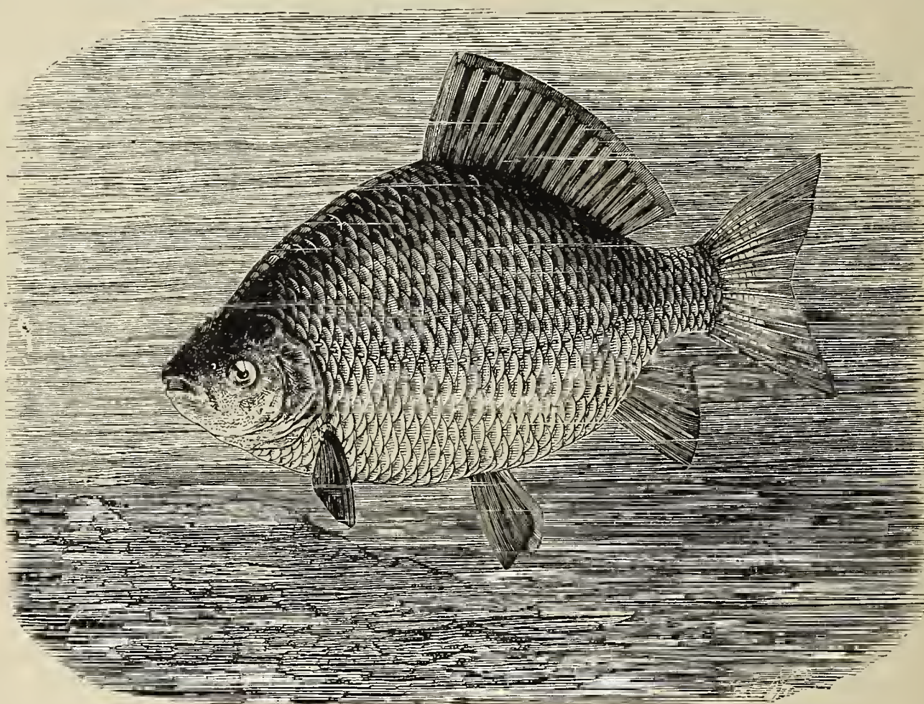
In the first of these three divisions the characters of the several groups are derived chiefly from the characters of the pharyngeal teeth, the modifications of the anal fin, position of the lateral line, and, in some cases, the dorsal fin also furnishes distinctive characters.

The first group, Catostomina, has the pharyngeal teeth numerous, close set, and arranged in a single series. There are no barbels. The dorsal fin is long, and the anal fin short.

In the type genus Catostomus the skeleton is remarkable, from the circumstance that many of the bones are so slightly ossified as to consist merely of a delicate bony network. This genus, like nearly all the other members of the group, is confined to North America, and comprises fishes of moderate size. Some of the species have the air-bladder with three divisions, as in Catostomus carpio, of the Canadian lakes.

The second group is termed Cyprinina. It has the pharyngeal teeth differently arranged in its representatives in the Old and New World. In the former, the teeth are placed in triple series; in the latter region of the globe the teeth may be in double, or even in single, series. The anal fin is very short, and includes five or six, or even seven, branched rays. The dorsal fin is opposite to the ventrals, and the lateral line runs along the middle of the tail. The scales are cycloid. This is the largest group of the family, and includes many familiar river fishes. The type genus is Cyprinus, which has a rounded blunt snout and narrow mouth, with four barbels; the dorsal fin has a strong serrated bony ray. The Carps are fishes of the temperate parts of Europe and Asia, the best known, Cyprinus carpio, presents a multitude of varieties in form, characters of skin and scales, and other features. It occurs not only throughout the northern part of Europe, but, according to Dr. Günther, in China, Japan,

Formosa, and Java. It does well in brackish water, and attains a large size in the Caspian Sea. The Carp is long-lived, and is believed to live to a hundred, or even to two hundred, years. In Germany the Carp is regarded with a degree of epicurean appreciation which, in this country, finds no parallel. In both Austria and Prussia they are as much an article of culture as any produce of the land. Carp ponds are somewhat costly to make, for there need to be separate ponds for spawning, for a nursery, and for the ordinary mature life of the fish; and it is stated that the sale of Carp makes no small part of the revenue of the larger landed proprietors in Northern Germany. A fish supposed to be sixty years old had a length of five feet. Other large Carp are referred to as weighing thirty-eight pounds and more. The Carp is tenacious of life, and in winter is kept alive in Holland for weeks, by being placed in wet moss which is hung in a net. The fish at first require to be frequently dipped in water, but gradually adapt themselves to the new condition, and feed on



THE CRUCIAN CARP.

bread and milk. The ordinary food of Carp consists of larvæ of insects, worms, and various water-plants. It has been known to feed on minnows. It becomes tame in the ponds, and readily assembles to take bread or boiled potatoes. In winter it hides in the mud, and passes months without eating. It breeds usually in the third year, but the number of eggs increase with age, and, in a fish of ten pounds' weight, the eggs number seven hundred thousand. The ova are deposited upon water-plants in May and June, and at this time the female is commonly followed by more than one male. They develop much better in ponds and lakes than in rivers. A remarkable account is quoted by Couch from the *Gentleman's Magazine* of a custom of removing the roe from the living fish, when they are said to acquire a flavour as much superior to that of ordinary Carp as the flesh of the ox is to that of bull, or a capon to a cock. Carp appear to have been introduced into England in the fifteenth century, probably by German monks. The Germans have a prejudice against allowing frogs to enter the Carp-ponds, and Couch, quoting Pennant, states that on fishing a pond in Dorsetshire great numbers of Carp were found, each with a frog mounted on it, the hind legs clinging to the back, and the fore legs fixed in the corner of each eye of the fish, which were thin and wasted. The colour of the body is golden-brown, darker on the head and upper

part of the body, and yellowish-white on the belly. The base of each scale is darker than its other part, and the fins are dark brown. The body is thick; there are two barbels at the upper part of each corner of the mouth, but the lower pair is the larger. The tail is forked. The dorsal and anal fins have a strong ray, which is serrated on the hinder margin.

The genus Carassius differs from Cyprinus in being without barbels. It is represented by the Crucian Carp — spread through Central and Northern Europe, Italy, and Siberia — and by the Carassius auratus, or Goldfish. The Crucian Carp (*Carassius vulgaris*) has the rather feeble stiff ray of the dorsal and anal fins finely serrated. In the Thames it sometimes weighs from one pound and a half to two pounds and a half. It is domesticated on the Continent, and exhibits many varieties. It spawns in June, when the fish assemble together in great numbers. In Siberia it becomes torpid in the winter, and is said to survive in the mud, even when the lakes freeze to the bottom. The scales are large. This species forms a hybrid with the common Carp. Dr. Günther regards the Prussian Carp as a lean variety of the Crucian Carp.

THE GOLD FISH.*

Gold and Silver fish are familiar pets, not only in the ponds of public gardens, but in the humbler aquaria of private houses. Thay are said first to have been brought to Europe in the seventeenth century, their original home being China, where they are kept in porcelain vessels for the amusement of ladies. The fish is naturalised in Portugal, and a large number of those which reach the London market are brought from Lisbon by trading ships. Blanchard states that in the rivers of France it loses its colour. In the manufacturing districts of England they are often kept in the ponds in which the water from the steam-engine is allowed to run off and cool. Here the average temperature is often about 80° Fahr., and Yarrell records that the fish breed much more readily under such circumstances than when exposed to the variations of climate. The species is apparently capable of enduring even a much higher temperature. Three pairs of fishes put into one of these warm ponds had, in three years, so increased in number that they were then taken out by the wheelbarrow-full. The varieties of colour and size are well exhibited in the collection at Hampton Court. The fins are no less variable than the colour; sometimes the anal fin is double, sometimes there are two, three, or four tails; the dorsal fin varies in length, and occasionally may even be absent; sometimes the eyes are very large and protruding, when the variety is termed the Telescope fish. No specimens are known to exceed a foot in length. A large number of allied genera, with the pharyngeal teeth in three series, occur in the Indian region. Among such are a species of the genus Catla, which occurs in the Ganges and Hooghly; Cirrhina, Dangila, Osteochilus, are other genera. The genus Labeo has the lips greatly thickened, and each possesses a sort of inner lip covered with a horny sheath which forms a sharp grasping edge, though it is not attached to the bone; the snout is covered with hollow tubercles. The occipital crest of the skull is firmly united to the neural spines of the earlier vertebræ. Some of the species occur in the Nile and other parts of Africa, others belong to the East Indian region. Another group of Carp is characterised by having the greater part of the cheek unprotected by bone. Among these, Discognathus presents a singular type in having the lower lip modified into a suctorial disc, and its pectoral fins are horizontal. The Discognathus lamta ranges through all the countries from Syria to Assam, and presents considerable variation in colour, form of the snout, barbels, lips, eyes, and tail. The Epalzeorhynchus callopterus, from Sumatra and Borneo, has the snout inflated and bluntly rounded, and furnished with a lateral lobe, which can be freely moved. The Capeota damascina is a well-known fish of Palestine, which occurs, not only in the Jordan and Lake of Galilee, but also in the Dead Sea, and has been found in Lake Van, in Asia Minor. The Syrian specimens sometimes reach a length of thirteen inches. The other species of this genus are mostly from Asia Minor.

The genus Barbus comprises about two hundred species of fishes, which vary a good deal in their characters. The dorsal fin generally has the third ray enlarged and ossified; it rarely includes more than nine branched rays, and is placed opposite to the root of the ventral fin. The anal fin is short and high. The barbels may be absent, as in some East Indian forms, but the larger number of the fishes have four barbels, though they are sometimes reduced to two. The best known species is the Barbel (*Barbus vulgaris*), a widely-distributed species in Europe, being plentiful in all the rivers which flow into the Black Sea, in the Weser, Elbe, Rhine, Thames, and most northern

* *Carassius auratus.*

waters. It burrows about in the loose soil on the river bottom, and feeds on worms, fresh-water mollusca, water-plants, and small fishes. The eggs are deposited in May or June on stones or water-plants in shallow water. They extend in a string, and may number eight thousand in a full-grown female. They are hatched in from ten days to a fortnight, and reproduce at the fourth year. In cold weather the fish becomes torpid and assembles in great numbers in sheltered places, when it is easily taken with a hand-net. It is even stated that in the Danube ten cart-loads have been taken at one time by divers, who captured the fish in their hands. The usual length is about fifteen inches, though it sometimes reaches three feet. It is stated by Heckel and Kner that the flesh is well flavoured when the fish has been previously kept for some days in pure water. The upper part of the body is greenish-brown, becoming yellower at the sides, and the belly is white. The caudal fins are brownish, and the pectoral, ventral, anal fins, and lips are red. The Barbel appears in the arms of Margaret of Anjou, Queen of Henry VI., foundress of Queen's College, Cambridge. Several species occur in Spain, Italy, Angola, the Jordan, and the Lake of Galilee, and a large number in the Indian Archipelago. A considerable group of species, found in India and Western Africa, is covered with very large scales. Barbus heteronema, from Borneo, has the barbels subdivided with long fringes.

The genus Barbichthys has the lips thin, with four small barbels; below the eyes the ring of sub-orbital bones is so greatly developed as to entirely cover the cheek. The only species known is from Java, Sumatra, and Borneo. Two genera, also from the Eastern Archipelago, are characterised by having the eyes surrounded with a broad circular fatty eyelid. The genera Oreinus and Schizothorax have the vent and anal fin enclosed in a sheath, which is covered with enlarged scales; the pharyngeal teeth are in three rows. Both genera are found in the mountain streams of the Himalayas and adjacent regions. Gymnocypris dobula is a Carp with the body naked, but the vent and anal fin are enclosed in a scaly sheath. Diptychus has the body only partly covered with scales. It also is Himalayan.

THE GUDGEON.*

The genus Gobio is entirely European, and is represented by only two species—Gobio uranoscopus, which is confined to Austria, and the Common Gudgeon, which is more characteristic of Western Europe. This well-known fish has two rows of pharyngeal teeth, which are hooked; there may be two teeth in each row, or five in one and three in the other. The barbels are small and placed at the corners of the mouth; the snout is blunt, the profile convex above, the eye behind the middle of the head. In this country it is found in most slow rivers that run over gravel, is gregarious, rarely exceeds eight inches in length, and is caught freely with the small red-worm. They are regarded as excellent eating, though, being small, are not much prized. The Gudgeon spawns in May. Yarrell quotes Valenciennes' experiment upon the effect of diminished pressure upon the Gudgeon, in which the fish were placed in a basin under the receiver of an air-pump. The fish could endure to have the pressure reduced to one-half, or even a quarter, without suffering, unless the exhaustion were too rapid, though on being returned to ordinary atmospheric conditions the belly appeared greatly shrunken, and the swim-bladder empty; but in six hours condition was restored, and the swim-bladder again filled with nitrogen gas.

Ceratichthys, Pimephales, Hyborhynchus, and many other genera are limited to North America. Cochlognathus ornatus, from Texas, is remarkable for the jaws being developed into spoon-shaped expansions, one on each side of the upper and lower jaw. These bony masses have their edges sharp and cutting so as to form a beak, which closely resembles that of Tetrodon.

The third group in this family is named Rotheichthyina. It includes fishes in which the dorsal fin is placed behind the ventral fin. The anal fin is very short, and the abdomen compressed; the mouth has no barbels, and the pharyngeal teeth are in a triple series. The only member of the group is the Rotheichthys microlepis, from Borneo and Sumatra.

The fourth group, named Leptobarbina, has the lateral line running along the lower halt of the tail; the dorsal fin is opposite to the ventral fin. There are four barbels. The only member of this group is the Leptobarbus hoevenii, also from Sumatra and Borneo.

The fifth group, named Rasborina, also has the lateral line on the lower half of the tail, but the dorsal fin is behind the origin of the ventrals, and the abdomen is not compressed. The fishes are

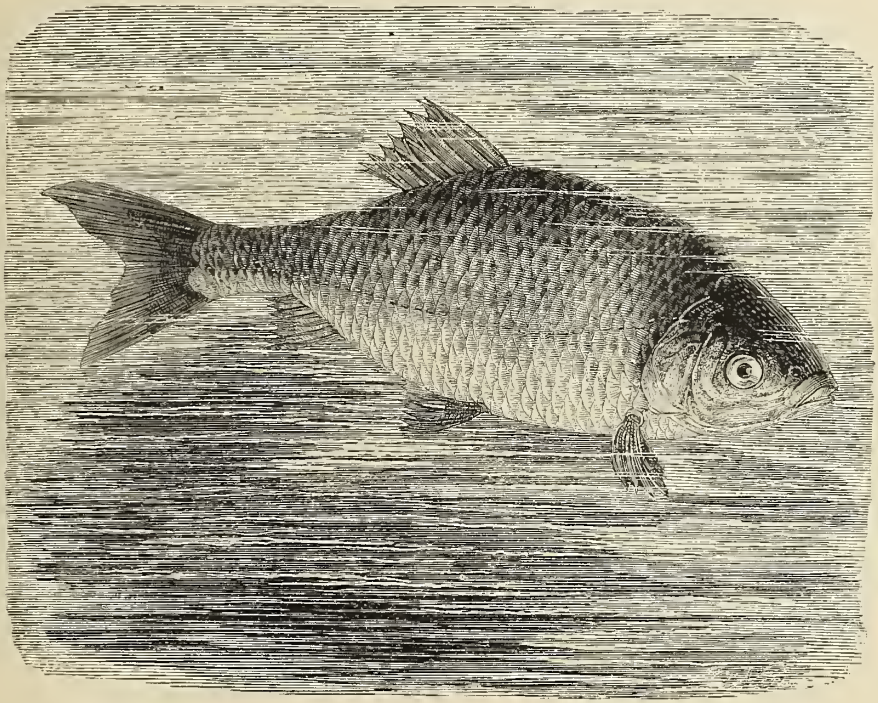
* *Gobio fluviatilis.*

chiefly from India, and the Indian Archipelago. One or two genera like Aphyocypris, from China, and Amblypharyngodon, have the lateral line incomplete. Some species of the genus Rasbora have barbels, though nearly all are without them.

The sixth group, named Semiplotina, includes the genera Cyprinion, from Syria and Persia, and Semiplotus, from Assam. The dorsal fin in these fishes is elongated, with an osseous ray and many-branched rays.

The seventh group, termed Xenocypridina, has an osseous ray in the dorsal fin, but the fin is short. Two of the genera are from China, and the third from the west coast of Sumatra.

The eighth group has the dorsal fin short, as in the preceding group, but the osseous ray is absent. It is named Leuciscina. The genus Leuciscus comprises the greater part of a hundred species, which are widely distributed in both the Old World and America. In this genus the body is



THE ROACH.

covered with imbricated scales. There are no barbels. The pharyngeal teeth are in a single or double series, and the intestine is short, with a few convolutions. The Roach (*Leuciscus rutilus*) belongs to the Old World section of the genus with the teeth in single series. It is found throughout Europe in all the countries north of the Alps. The body is somewhat elevated, of a silvery aspect, and has three longitudinal rows of scales between the lateral line and the ventral fin. In the full-grown fish the lower fins have a red colour. Its usual length is ten inches, but large specimens may measure as much as fifteen inches. The large scales are easily detached; the lateral line has a downward curve. The mouth is small. The Roach is a gregarious fish, swimming in large schools, and as the reproductive season approaches they make a short migration, leaving the lakes or main streams to ascend the tributaries, and at such times are taken in great numbers. Their eggs furnish food for the Trout. At ordinary times the Roach frequents holes in the beds of rivers. In the Baltic they are said sometimes to be met with in bays near to the land. It is in the best condition for table in October, but is not greatly valued as food. This species forms various hybrids with Breams.

Many species of Leuciscus occur in Spain, Portugal, Montenegro, Dalmatia, European Turkey,

the Crimea, and Danube. The Leuciscus zeregi is a small fish two inches and a half long, from the Lake of Galilee.

The Chub (*Leuciscus cephalus*) occurs throughout the fresh waters of Europe and Asia Minor. It is common in the Thames, and many of the rivers of England, preferring rapid waters with a clean bed. It seeks shelter in holes equally from the heat of summer and the cold of winter. It, as a rule, takes a mixed diet, made up partly of insects undergoing their metamorphosis in the water, partly of worms and water-plants. It spawns towards the beginning of summer. It does not reach a larger size than a weight of five pounds, and is held in no favour for eating, though Yarrell states it is best when broiled with its scales on. The scales are large and thick ; the lateral line is concave in length. The colour is a brownish-green, becoming paler on the sides ; the tail and lower fins are reddish.

The Dace (*Leuciscus vulgaris*) has an oblong body, with a moderately broad head and narrow mouth ; the middle sub-orbital bones are very narrow. The origin of the dorsal fin is opposite to the hinder part of the root of the ventral fin. The sides have a shining, silvery appearance. There are four longitudinal rows of scales between the ventral fin and the lateral line. The pharyngeal teeth are hooked. It is found in Europe only, and ranges from Lapland southward to the Alps. When fully grown, it is eight or nine inches long, and somewhat resembles the Roach in appearance. It prefers clear streams where the water is deep and the bottom gravelly. Its habit is gregarious ; it feeds on worms, and many kinds of soft food. It spawns in early summer. Its flesh is but little valued, though it is preferred to the Roach. Dr. Günther regards the Graining which Yarrell described as Leuciscus lancastriensis as a variety of the Dace. Yarrell remarks that the nose is rounder than that of the Dace, the eye larger, the profile of the head straighter, the scales larger, and enumerates various minor differences.

The Ide (*Leuciscus idus*) is a well-known European fish found in the brackish waters of the Baltic, and ranging through the Scandinavian countries, Germany, and Austria. It is also said to have been taken at the mouth of the river Nith, in Scotland. It is a very variable species, with the jaws even in front, and the body slightly elevated. In Sweden, examples have weighed four or five pounds. When boiled in salt water the flesh becomes red, like that of the Salmon. The sides of the fish are typically bluish-grey, but the variety named Orfus is of a uniform orange colour.

The Red-eye, or Rudd (*Leuciscus erythrophthalmus*), is another fish with an elevated body ; the part of the belly behind the ventral fins is compressed into a sharp edge, and covered by scales which extend across it. The origin of the dorsal fin is behind the root of the ventral fin. There are three rows of scales between the ventral fin and the lateral line. It is a widely distributed species, occurring in Britain, throughout Europe, and in Asia Minor. Its eyes are bright-red, and the fins are red also, though the colour is more marked in the lower fins than in the upper ones. The body is brown, or sometimes bluish-green. The variety termed the Azurine is remarkable for its blue colour. It is preyed upon by Pike, Trout, and Perch ; is good eating, but does not reach a greater weight than two pounds. As in many allied species, the scales become rough at spawning time. There are several hybrids between this species and other allied fishes.

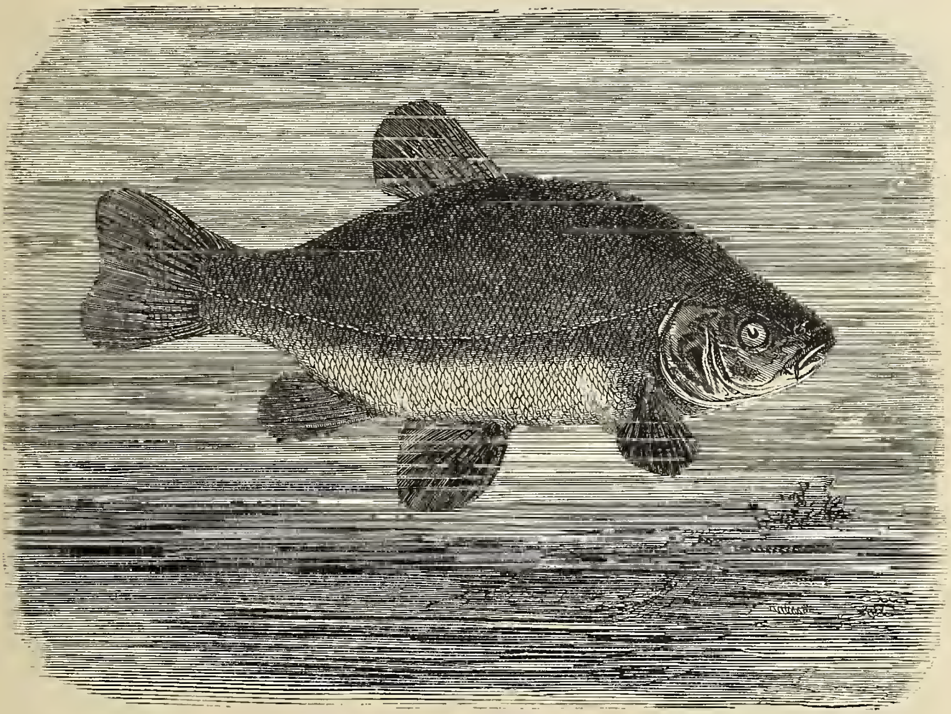
The Leuciscus muticellus is a well-known species in the upper parts of the Danube and Rhine, Switzerland, and Italy.

The Minnow (*Leuciscus phoxinus*) is a widely-distributed European fish, ranging from Norway to the Danube, and well known in England. It is the smallest British species of the family. Almost every fish in the river preys upon it. The Minnows have a remarkable habit of arranging themselves in circles, with the snout towards the centre, when any substance which can serve as food is thrown in the water. This arrangement has been compared to the petals of a flower. The Minnow rarely exceeds a length of three inches. The flavour is good, especially when fried, but they can only be taken in sufficient quantity for a meal with a net. They spawn in June on gravelly soil, and are hatched in a few days. The dorsal fin is opposite the space between the ventral and anal fins. The tail is forked, and there is a blackish spot at its base, with many spots extending along the middle of the body, which is otherwise of an olive-brown, becoming lighter at the sides. In summer the belly acquires a pink tint. The pharyngeal teeth are claw-shaped.

More than half the species of Leuciscus occur in America, where they are widely distributed in

the United States. Very few have acquired popular names, but among these is the Red-fin, also known as the Red Dace, or Rough-head (*Leuciscus cornutus*), the fins becoming red during the spawning season. It is found in Lakes Erie and Michigan, and other parts of the United States. The Spawn-eater, or Smelt (*Leuciscus hudsonicus*), is a silvery fish with a black spot on the root of the tail, and with a very large eye. It is about three inches long, and occurs in Lake Superior. Many of the American species have the eye large.

The Tench (*Tinca vulgaris*) is the only species of its genus. It has small scales, which are deeply embedded in a thick skin covered with thick mucus. The dorsal fin is short, and has no spine. It is opposite to the ventral fin. There is a short barbel at the angle of the mouth. The pharyngeal teeth are in a single row, are cuneiform, and slightly hooked. It occurs in France, Germany, and



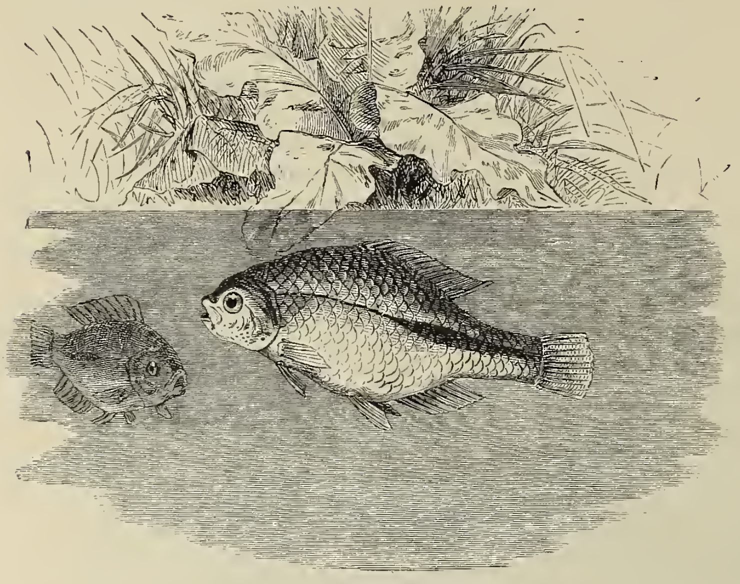
THE TENCH.

Austria, especially in the lakes; it is not abundant in the English rivers, but is often found in old pits in brick-yards, and muddy places generally. They are fattened on meal when preparing for table, and are a well-flavoured fish. The Tench is tenacious of life, and is usually brought alive to market in the midland counties. Tench have been taken thirty-three inches long, weighing eleven to twelve pounds. In the colder months this fish shelters itself in a hole which it excavates in the mud. In stocking Tench ponds two males should be allowed to every female. The eggs are deposited on weeds in June, and hatched in two or three days. There are three hundred thousand ova in a fish weighing four pounds.

In the genus Chondrostoma, which is well represented in Western Asia and Europe, the lower jaw has a sharp cutting edge over which there is a brown horny covering.

The ninth group is named Rhodeina. It is a small assemblage of fishes, some of which are from China and Japan, while the remainder are European. The most important genus is Rhodeus, well known on the Continent from the *Rhodeus amarus*, which has a silvery-bluish band on the middle of the tail, as in the Chinese species. It is sometimes found in warm springs. The female at the spawning time develops a remarkable tube external to the body, and often two-thirds as long as the fish. Down this tube the eggs pass, and specimens are sometimes seen in the Strasburg market with

the tube filled with yellow ova. After spawning, this appendage is gradually absorbed, till its former position is only indicated by a papilla.



RHODEUS AMARUS.

The tenth group is named from the typical genus Danio, Danionina. It has the lateral line on the lower half of the tail. The genera are distinguished by the form of the mouth, teeth, sub-orbital bones, and presence or absence of barbels. The species are mostly small, and are from the Indian region, though several occur in China and Japan, and one or two are from Western Africa.

The eleventh group rejoices in the name Hypophthalmichthyina. It included only two species of Chinese fishes of the genus Hypophthalmichthys, which has the anal fin long.

The twelfth group, termed Abramidina, also has the anal fin long, but the abdomen, or at least part of it, is compressed into a sharp edge.

This is a somewhat large group of fishes comprising many genera. One of the best known is

THE BREAM.*

This is a species confined to the North of Europe, though also met with in the Pyrenees. It is distinguished by the compressed elevated form of its body, with a short blunt snout, and the dorsal fin is so placed that its last ray is above the beginning of the anal fin. The lateral line is low down on the side, and includes from forty-eight to fifty-two scales. There are twelve rows of scales above it and six below. The scales are pearly and the colour is whitish, but the slight yellow tinge deepens into brown with age. The pectoral and ventral fins have a reddish tinge, and the other fins are somewhat brown. The three vertebræ next to the head have no ribs, and may therefore be termed neck vertebræ; then follow fifteen abdominal vertebræ, carrying ribs, and there are twenty-one in the tail. The species abounds in England and Ireland in rivers, lakes, and canals, swimming in immense shoals. The spawn is deposited in May, when the eggs of a single fish number a hundred and thirty thousand. As many as four males follow one female when she is depositing the spawn. The fish is more valued for food on the Continent than in this country. The usual size runs from two to four pounds, but large specimens reach a weight of fourteen pounds or more. This species is tenacious of life, and can endure great cold. It is reputed to be shy, and in Sweden in many parishes the church bells are not rung during the fishing season, for fear of driving the Bream away from the adjacent waters.

There are several other species found on the Continent which range southward to the Danube. The White Bream (*Abramis blicca*) is a well-known British species which ranges from the Danube to Lapland. It is a smaller fish than the common Bream, and rarely exceeds a foot in length. Like most of the allied fishes, it feeds voraciously on worms, insects, and water-plants, and is itself largely preyed upon by the Pike. When it seizes the bait of the angler, it rises towards the surface, so that the float, instead of descending, lies flat on the water. It has fewer scales than the common Bream, there being nine rows above the lateral line and five below it. The colour is silvery-white, sometimes with a bluish tinge.

* *Abramis brama.*

The so-called Pomeranian Bream is regarded by Dr. Günther as a hybrid between Abramis brama and Leuciscus rutilus, having more in common with the Roach than the Bream.

THE BLEAK.*

This is a fish of much more elongated body than the foregoing. Its lower jaw projects beyond the upper jaw, which is protractile. The pharyngeal teeth are in two series, and hooked; behind the ventral fins the belly is compressed into a sharp edge across which the scales do not extend. It is a very active little fish, rarely growing to a greater length than seven inches; its back varies from a greenish to a brownish tinge, but the rest of the body is silvery-white and shining. This appearance is due to a pigment which exists on the inner surface of the scales, and is like that which gives brilliance to the Whitebait and Roach. This pigment has been utilised in the manufacture of artificial pearls, and in Paris is known as Essence de l'Orient. The scales are scraped off, washed, and triturated, when the pigment falls to the bottom of the water. Ammonia is added to separate the animal matter. The substance is then mixed with fish gelatine, and spread on beads of glass or plaster. At first the artificial pearls are almost, if not quite, equal in beauty to real pearls, but the pigment soon comes off on to the neck of the lady who adorns herself with them. In England the Bleak pigment was formerly largely used to wash over the cavities of thin glass beads, which were afterwards strengthened by being filled with wax. The use of Bleak for these purposes originated in Europe with the Venetians, in the sixteenth century, but the industry was prohibited by the Government. It was probably derived from China, where the art has been practised from time immemorial.

The East Indian genus, Osteobrama, has a large serrated dorsal spine, and a bipartite air-bladder. Chanodichthys is a genus from China and Formosa, which has the air-bladder tripartite, and, according to Dr. Günther, in one species at least has no liver. Chela is a genus with slender pharyngeal teeth, represented by many species in the East Indies.

The thirteenth group is named Homalopterina. It is chiefly distinguished by having no air-bladder. It includes four genera, which are from the East Indian region. The species are small.

The fourteenth and last group of the Cyprinidæ, named Cobitina, has the air-bladder more or less completely enveloped in a bony sheath. The mouth is surrounded by not fewer than six barbels. The scales, when present, are small, and are sometimes entirely absent. In the genus Misgurnus the barbels are from ten to twelve in number, and the scales are more prominent than in other members of the group. The genus Nemachilus, however, has only six barbels; the best known example in this country is the Loach (*Nemachilus barbatulus*). The air-bladder in this fish is small, and placed immediately above the entrance to the gullet in bony capsules, situate on each side of the bodies of the first two vertebræ. These capsules are circular, smooth on the inside, and have a slit on their outer margin, and are probably connected in function with the organ of hearing. Yarrell remarks that the parietal bones in the median line of the skull have an interspace between them, which in the living fish is occupied by cartilage. The length of the fish at its largest may be as much as five inches. It is covered with a slimy mucus secretion. It is widely distributed in Britain and Central Europe, but is not found in Scandinavia or Denmark. It frequents brooks and small shallow rapid streams, hiding itself under stones. In stormy weather this fish rises to the surface, apparently in expectation of the feast of insects then to be found on the surface of the water. The flesh of the Loach is everywhere esteemed as one of the greatest delicacies. All the members of the Loach family, especially this species, the Spinous Loach, and the Misgurnus fossilis, possess the remarkable habit of using the intestines as a supplementary breathing organ. Atmospheric air is swallowed, and, after passing through the intestines, is found to be largely charged with carbonic acid, but Siebold states that this method of respiration in only habitually used when the fish are in muddy waters. The caudal fin is truncate. The dorsal fin is in the middle of the body, and both these fins are marked with dark spots, arranged in cross bands. The back and sides of the body are marked with dark brown.

There are many species of this genus, ranging from the Lake of Galilee through Asia Minor and the Indian region. The Nemachilus stolickæ is found in the Lake Tsumureri, in Tibet, at a height of 15,500 feet above the level of the sea.

The Spinous Loach (*Cobitis tænia*) is a rarer fish in this country, and is unknown in Ireland. It

* *Alburnus lucidus.*

especially affects muddy positions. It carries a small bifid spine below the eye, which is capable of being elevated by the fish at will. The body is considerably compressed; like all the allied fishes it emits sounds when touched. The length is about three inches; the barbels are remarkably short; there is a row of large brown spots on the side of the body, and a brown streak running from the eye to the end of the snout. It is less valued for food than the common Loach. This species, though characteristic of Europe, appears also to occur in Japan. In the genus Botia the air-bladder is divided into two parts; the anterior division is only partly contained in an osseous capsule, and the hinder portion is free and suspended in the abdominal cavity.

CHAPTER VII.

PHYSOSTOMI (*concluded*)—CYCLOSTOMATA—LEPTOCARDII.

Gonorhynchidæ—Hyodontidæ—Osteoglossidæ—Clupeidæ—The Anchovy—The Herring—The Fisheries—The Boat and Nets—The Whitebait—The Sprat—The Shad—The Pilchard—The Pilchard Fishery—Chirocentridæ—Alepocephalidæ—Notopteridæ—Halosauridæ—Gymnotidæ—The Electric Eel—Electric Organs—Effects of the Shock—Symbranchidæ—Murænidæ—Characters—Various Types—The Sharp-nosed Eel—Weight—Habits—The Broad-nosed Eel—The Conger Eel—Characters—Prehensile Power of its Tail—Habits—The Genus Muræna—Pegasidæ—CYCLOSTOMATA — Characters — MARSIPOBRANCHII — Petromyzontidæ — Characters—The Sea Lamprey—Distinctive Features—Great Suctorial Power—Distribution—The Lampern, or River Lamprey—The Sand-piper—Myxinidæ—Characters—The Hag—Distinctive Features—Remarkable Nostril Character—Its Enormous Mucous Secretion—LEPTOCARDII—Cirrostomi—The Lancelet—Size—Characters—Peculiar Heart and Blood—Difficulty connected with it and Hag—FOSSIL FISHES.

FAMILY XVIII.—GONORHYNCHIDÆ.

This family contains only a single species, Gonorhynchus greyi, a marine fish found only at the Cape of Good Hope and in Australian and Japanese waters. It is covered with small spiny scales, and has barbels to the mouth; the dorsal and anal fins are both short; the air-bladder is absent. The large eye is covered by transparent skin; there are no teeth either on the jaws or on the palate, but patches of teeth are developed on the pterygoid bones and on the hyoid bone. It is about a foot long.

FAMILY XIX.—HYODONTIDÆ.

The Hyodontidæ comprise only the American fish termed the Moon-Eye (*Hyodon tergisus*), found in the fresh waters of North America, especially in the great lakes. It is covered with silvery cycloid scales, but has the head naked. The stomach is horseshoe-shaped, the body is oblong.

FAMILY XX.—OSTEOGLOSSIDÆ.

This is a small group of fresh-water fishes from the Tropics. The body in these large fishes is covered with scales, which are thick, and arranged like pieces of mosaic, though they are absent from the head, where the skin is almost entirely replaced by bone. The dorsal fin is on the caudal region, and opposite to the anal fin; sometimes both these fins are confluent with the caudal.

The genus Osteoglossum is found in the fresh waters of Queensland, the Indian Archipelago, and Tropical America. Arapaima gigas is a large fish from Brazil and British Guiana. The head is less than one-fourth of the total length. Specimens in the British Museum are eight feet long, but it is sometimes nearly twice that length, and weighs 400 lbs. It is often captured with the hook, but frequently killed by the Indians with the bow and arrow. A number of men and boys go out in small boats, and when the fish is seen shoot at it. Of course it instantly disappears, but is followed up and shot at again and again, till, at length becoming exhausted, it is easily captured. The flesh is not very appetising, but is salted and dried by the natives and exported. In the allied Heterotis niloticus of Tropical Africa the stomach consists of two distinct portions, one membranous and the other muscular; the air-bladder is cellular, and the fourth branchial arch carries a spiral organ. These fishes are often three feet long.

FAMILY XXI.—CLUPEIDÆ.

This family is scarcely inferior in importance to any other group of fishes in the supply of human food. Its varied forms have led the family to be subdivided into seven groups, comprising in all more

than 150 species. These fishes are widely distributed in all seas, especially on coasts, and many of the species enter rivers. In all of them the head is naked and the body covered with scales; the maxillary bones are formed of three pieces, which are sometimes movable, and constitute the lateral parts of the jaws, the pre-maxillaries forming the middle part in front. The stomach is furnished with a pouch, and there are numerous pyloric appendages. The pseudobranchii are large, except in one genus, Megalops, where they are rudimentary or absent. In the first group, termed Engraulina, the pre-maxillary bone is remarkably small and firmly united to the maxillary; the upper jaw projects, and the mouth is wide. The best known member of this group is

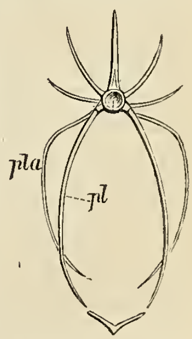
THE ANCHOVY.*

This is a fish with an elongated body and pointed snout, which projects well beyond the lower jaw. The teeth in the maxillary bone are very small, and there are teeth on the vomer, palatine bones, and pterygoids. The abdomen is rounded, and, like the sides of the body, silvery. A black stripe divides the colour of the sides from the dark tint of the back. The tail is forked. The species is widely distributed on the European coasts, and especially all through the Mediterranean and Black Sea. It is met with in the English Channel, and has been taken in the Thames and at Yarmouth. It occasionally visits Norway and the Baltic and Davis Straits. A variety of this fish ranges into the South Pacific, being taken in Tasmania and New Zealand. The greatest length of the Anchovy is eight inches. Most of the Anchovies consumed in this country come preserved in oil or salt and water, and they form the principal, though not always sole, ingredient in anchovy sauce. They are taken in immense numbers on the coasts of Spain, France, and Portugal from May to July, when the fish has come into the Mediterranean from the Atlantic, to which it is believed to return after depositing its spawn. Fishing is carried on at night, when the fish are attracted by lights, and then the seine-net is spread round the spot where they have congregated. Couch is of opinion that a sufficient quantity of Anchovies might be taken in British waters to supply the demand in this country if the fishing were carried on in a proper way. Several species of the genus are taken in the rivers of South America, but the genus is best represented in the West Indies and adjacent coast, and in the East Indian region. Forty-three species of Anchovies are known. The second group of the Clupeidæ is termed Chatoëssina. It has the narrow mouth toothless and the abdomen serrated. The species occur on the coast and rivers of India, China, Australia, and North and Central America.

The third group, Clupeina, has no conspicuous difference in the length of the jaws, and the abdomen is serrated. It includes a multitude of species chiefly referable to the genus Clupea. They inhabit the shores of every part of the world, and many species are found in rivers.

THE HERRING.†

This species is widely distributed in the North Atlantic, both on the European and American shores, and extends along the northern coast of Asia. Herrings have been found plentifully in Delaware Bay, and occur both in the Black Sea and, according to some writers, in the Caspian, though the latter specimens are probably the well-known Clupea caspia, which is limited to the Caspian, and is intermediate between the Herrings and the Shads. Large examples of Herring may be fifteen inches long. The fish is too well known to need a detailed description. The accompanying figure shows the spinous processes and ribs (*pl*) of this fish. There are about twenty pyloric appendages to the stomach. It feeds chiefly on the more minute crustacea, but many kinds of young fishes have been found in its stomach. In the Outer Hebrides, which is one of the great fishing stations for the Herring, the fishery is forbidden by law before the 20th of May; but in the Shetland Isles the fish do not commonly appear in any number till July. On the east of Scotland they abound in August, September, and October. In the West of England they are usually plentiful in October and November, but in some years appear earlier or continue later. Nothing certain is known of the cause of the migration of the Herring, and from time to time it changes its course, so that many years may elapse without its ever being seen on coasts which it formerly frequented. The numbers taken, however, are almost incalculable. In Scotland alone half a million of

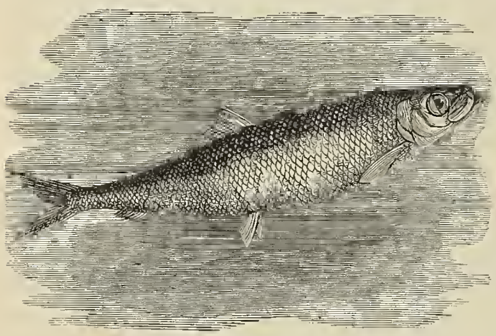


VERTEBRA OF HERRING. (*After Owen.*)
pl, Rib; *pla*, Appendage of Rib.

* *Engraulis encrasicholus.* † *Clupea harengus.*

barrels are said to be prepared for exportation every year. Each barrel contains 550 full-grown fish. The female contains about 70,000 eggs, and spawns in the early part of November. The spawn is deposited on the sea bed, and is discharged in a mass, which adheres firmly to the rocks. The young are found abundant in a fortnight to three weeks, and in six weeks are three inches long. The Herring fishery dates back to Anglo-Saxon times, when towns on the east coast paid their taxes in Herrings. Yarmouth cannot be said, like Amsterdam, to be built on herring bones, but is a well-known centre of Herring industry. The charter of the town requires the corporation to deliver to the sheriffs of Norwich a hundred Herrings baked into twenty-four pasties, that they might be delivered to the lord of the manor of East Carlton. The fish are easily alarmed by noise, and rush away to a distance of five or six feet, but rarely spring in the water like Pilchards. The fish are usually sold to professional curers, who prepare them in a variety of ways, which are well known in this country, and the curing alone gives employment to many thousands of people. On the Continent the Herring is also highly prized, and sometimes is preserved moist, with spices, salt, and other condiments, and is often eaten uncooked.

The Herring fishery is usually carried on by means of the drift-net, which is made of cotton or hemp twine. These nets are largely made at Bridport. The cotton nets are the more flexible, and are prepared for use by being first soaked in linseed oil, and then either boiled in oak-bark liquor for two or three days, or a preparation of catechu, but they are sometimes dressed with coal-tar instead. The net consists of one piece, which is thirty yards long. It is fastened to a small line about eighteen or twenty yards long, so that the netting is slack. The back of the net is fastened at short intervals to a small double rope, which encloses pieces of cork, so as to keep that part of the net uppermost. A single vessel, according to her size, may use from eighty to a hundred and thirty of such nets. They are connected together in succession, and often extend for a length of a mile, or a mile and a quarter. The meshes are about an inch, or rather more, in diameter, but in old nets the size becomes less. The twine nets last longer than those of cotton, are generally barked once or twice in the season, but never tarred. A fishing boat carries two sets of nets—one with many cork floats, to be used when the fish are near the top of the water, and the other with few corks, which is used when the fish are swimming at some depth. The whole of the train of nets is made fast to the vessel by a moderately strong rope, technically called a warp. These nets are used almost entirely at night. The vessels employed are all small, the largest being about thirty-six tons. The number of men in the larger boats is usually from nine to eleven. When the fish are plentiful the nets remain but a short time in the water—are hauled in and shot out again. The fish, when got on board, fall on the deck, are sprinkled with salt, and are stowed away in compartments called the "wings" of the hold. If fish have been plentiful the mast is put up when the night's fishing is over, the vessel makes sail, and returns to port; but if fish are scarce, the smack seeks fresh ground for another night's work. Good fishing ground is generally indicated by the abundance of sea-birds, Dog-fish, and Cetacea, which follow the fishes, and feed upon them. Some tropical species of Herring are poisonous.



THE HERRING.

A good deal of difference of opinion has prevailed as to whether the Whitebait is a distinct species. Yarrell believed it to be distinct, as do Jenyns and Couch, but Dr. Günther remarks emphatically that all the examples of Whitebait that he has examined are young Herrings.

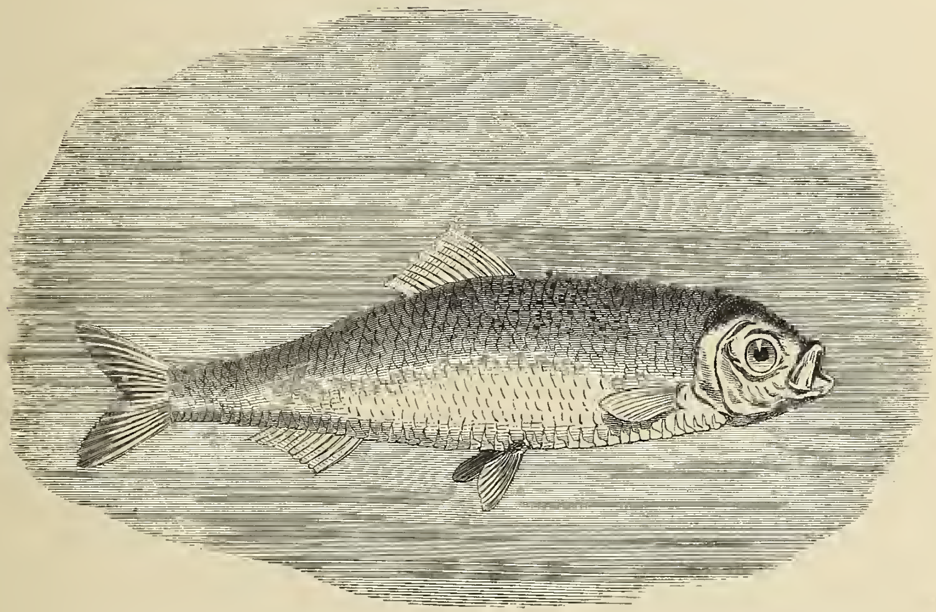
This fish is taken in the Thames from April to September, and abounds especially off the Northern coast. The net with which they are caught has a mouth about three feet square. The bag-end of the net is very narrow, and the mesh of the net is very small. The boat is moored in the tide-way, where the water is from twenty to thirty feet deep. The small end of the net is from time to time taken into the boat and untied, when its contents are shaken out.

The Sprat (*Clupea sprattus*) is a very distinct species from the Herring. It is well known on the

Atlantic coast of Europe, and extends into the Baltic and western half of the Mediterranean. It does not appear to take the hook, and is usually captured with the stow-net, the meshes of which must not be less than half an inch from knot to knot. The quantity caught far exceeds the demand, and in many localities they are used for manure. The Sprat, when full grown, is six inches long, but its ordinary length is three inches. The scales are smooth, and are easily shed. The lower jaw is prominent. There is an oval patch of small teeth on the tongue. The abdomen is serrated in front of the ventral fin, as well as behind. The tail is deeply forked.

In the Baltic it is preserved with spices, and eaten as a relish for lunch. There are from forty-seven to forty-nine vertebræ in the Sprat. In the Herring there are fifty-six. Other species occur in the Mediterranean, West Indies, United States, Indian Archipelago, China, and Australia.

The Shad (*Clupea alosa*) is commonly called the Allice Shad. It is especially distinguished by having from sixty to eighty long, very fine gill-rakers on the horizontal part of the outer branchial arch.



THE SPRAT.

It is frequently met with on the European coasts, and occurs in the Mediterranean. The flavour improves after they have been some time in a river. Excellent Shad are found in the Severn, where they are caught in April and May. It occasionally is taken as high up as Worcester. At sea it is often caught on lines with a Mackerel bait. It sometimes reaches as great a length as four feet; two feet is a commoner size. It is a fish deeper in the body than the Herring. The back is blue and the belly silvery, becoming more or less reddish. The closely allied Clupea finta has about five-and-twenty stout osseous gill-rakers on the horizontal part of the outer branchial arch. In this country it is usually known as the Twaite Shad. It enters our rivers in May, and returns to the sea by the end of July. Its ordinary length is from twelve to sixteen inches. It is found in the Nile.

The Pilchards (*Clupea pilchardus*), distinguished by radiating ridges on the operculum, especially frequent the Mediterranean, and adjacent parts of the Atlantic, and extend northward to England and Sweden, but rarely wander into the Bristol Channel, or as far east as the Straits of Dover. They are never absent from the coast of Cornwall, though in winter the fish keep near to the bottom. In spring they begin to congregate, and in July the great shoals are met with. The fishery, with the seine-net, begins in August, and lasts till the rough weather of the equinoctial gales puts an end to it. Some Pilchards spawn in May, others in October; but there is no reason for suspecting that they spawn twice in the year. Yarrell found that their stomachs are often crammed with a small

species of shrimp no larger than a flea. Couch believes that the spawn is shed on the surface of the water, and remarks that after spawning a sheet of jelly, full of eggs, has been seen extending for several miles in length, and fully a mile in breadth, over the surface of the water, but no thicker than brown paper, and so tough as not to be easily torn.

The French fishermen endeavour to attract the Pilchards to the drift-nets, which they use, by scattering the salted roe of Cod and Ling. It is said that the fish are so easily alarmed by noise that the firing of a cannon at a distance of twenty miles has caused them to sink into deeper water, hence all the proceedings of the fishermen are arranged by signs. The Pilchard is sometimes eleven inches long; it is a thicker and smaller fish than the Herring. The upper part of the body is bluish-green, and the belly and sides silvery-white. It is largely cured for exportation. Dr. Günther distinguishes two varieties, first, the Sardine of the Mediterranean, and secondly, the Pilchard of Cornwall.

The Pilchard is closely represented on both sides of the Pacific by a variety named Clupea sagax.

The seine-net appears to have been used from the earliest times in the Pilchard fishery. It is used to surround the fish in the sea when they appear in shoals. In the Pilchard fishery two or three nets are sometimes used in enclosing the shoal. The principal net is about 200 fathoms long, and ten fathoms deep. To this seine another net is united, which is 100 fathoms long, and is called the stop-seine. There is a boat with each net, and, starting from the same place, the boats move in different directions. The seine is carried outside the shoal parallel to the shore, and brought round towards it by these boats. The stop-net is then shot out towards the land across the direction in which the fish are moving, so as to intercept them. The end of this net is then brought round towards the large seine, and the circle is completed. The stop-nets, if more than one has been used, are afterwards taken out, and the seine is drawn towards a quiet part of the shore, till it grounds, and is moored. The fish are removed from this net with a smaller one called the tuck-seine, which, however, may be seventy or eighty fathoms long, and eight to ten fathoms deep. It is so placed as to get the net under the fish, when they are brought to the surface, put in baskets, and taken on shore. At St. Ives, in Cornwall, the Pilchards are sometimes taken in such quantities that several days may be required for landing the fish from a single net. The Oil Sardine is caught on the east coast of India.

The fourth group of the Clupeidæ is named Dussumieriina. It is a small assemblage of fishes, chiefly found in the East Indies, though one or two species occur on the Atlantic coasts of America.

The fifth group, Albulina, is formed for the Albula conorhynchus, a fish with a conical snout, of a uniform silvery appearance, a compressed oblong body, and flat abdomen. It ranges throughout the tropical and sub-tropical seas, being found in the Atlantic, Indian Ocean, and Pacific.

The sixth group (Elopina) has the upper jaw shorter than the lower, and with a narrow osseous plate covering the space between the mandibles. It includes the genera Elops and Megalops, both found in tropical and sub-tropical waters. The two species of Megalops, both five feet long, enter rivers.

The seventh group, called Chanina, has no teeth. It includes only the two species of the genus Chanos. In this genus the mucous membrane of the œsophagus is raised into a spiral fold.

FAMILY XXII.—CHIROCENTRIDÆ.

This family comprises the one species Chirocentrus dorab, three feet long, in which the air-bladder is incompletely divided into cells. It occurs in the Indian Ocean and Archipelago from Africa eastward, and in the Chinese and Japanese Seas.

FAMILY XXIII.—ALEPOCEPHALIDÆ.

The type of this family is the Alepocephalus rostratus, a deep-sea fish from the Mediterranean, in which the air-bladder is absent. Externally it is of a blackish-brown colour, and is remarkable for having the inside of the mouth and abdominal cavity black. Three other genera are known.

FAMILY XXIV.—NOTOPTERIDÆ.

This family comprises the genus Notopterus, which is distributed in the fresh waters of India and the Indian Archipelago, and has two species on the west coast of Africa. The tail in this type is long and tapering, the anal fin is very long, the air-bladder is divided in the interior, terminating at each end in a pair of horns, those in front being connected with the auditory organ.

FAMILY XXV.—HALOSAURIDÆ.

This family has but one genus, the Halosaurus. Both body and head are covered with cycloid scales; the long body terminates in an exceedingly long tapering tail; the snout projects far beyond the mouth. There is only one and a half series of scales between the lateral line and the ventral fin. Halosaurus Oweni is found at Madeira. Other species range down to a depth of 2,750 fathoms.

FAMILY XXVI.—GYMNOTIDÆ.

This family includes a small assemblage of fishes having a long eel-shaped body, a long anal fin, no ventral fin, and a tapering tail, the extremity of which is capable of being reproduced.

The ribs are well developed, the air-bladder is double, and the vent is near to the throat. All these fishes are confined to the fresh waters of the tropics, abounding in Brazil and the Guianas. Only one member of the family—the Electric Eel (*Gymnotus electricus*)—possesses electric properties. It is the only species which is entirely devoid of scales; it possesses a single row of conical teeth; the dorsal and caudal fins are entirely absent, but the anal fin is prolonged to the end of the tail.

The electric organ is placed on each side of the lower part of the tail, reaching forward to the vent, and forming a third of the weight of the animal. The colour of the fish is blackish above, but the belly is of a paler and reddish tinge. Ill-defined spots frequently extend along the back and sides. The length varies from three to six or seven feet. The experience of observers has varied as to the effects of the electric power of the fish, but it seems to be agreed that if it be picked up by the tail sensations of an acute and painful character are felt and do not immediately pass away. It is well known that cats and dogs perform remarkable feats of a gymnastic character after the incautious examination of this animal. It is shunned by the other inhabitants of the river, and dreaded by the Indians, who, nevertheless, overcome their scruples when the animal is dead, for the muscles are accounted palatable, though the flavour of the electric organ is unpleasant.

The shock is said to be sufficiently powerful, in the case of large fishes, to paralyse horses and kill small animals, and is much more severe than the shock from the torpedo. The discharge takes place apparently under the action of the will. In South America wild horses have been driven into the rivers by parties travelling, so that the fishes might exhaust their energies on the horses before the men ventured in the water. The fish sometimes die from excessive exhaustion, but usually regain the electric energy in a few hours. The two ends of the fish are in opposite electrical conditions, so that the most powerful shock is received when contributed to by the head and tail of the fish. The electric nerves are very numerous, and belong partly to the fifth pair, and partly to the intercostal series.

The Electric Eel does not often eat the fishes killed by its shocks.

The other genera in this family are all covered with scales. Sternarchus has the tail terminating in a small caudal fin, and there is a rudimentary dorsal fin attached by a band of fat to a groove in the back of the tail; but in Rhamphichthys, Sternopygus, and Carapus the tail terminates in a free point. Several species of the genera Sternarchus and Rhamphichthys have the snout produced into a more or less long tube.

FAMILY XXVII.—SYMBRANCHIDÆ.

This is a small and varied group of Eel-like fishes, which have the body naked or only covered with minute scales; the upper jaw is entirely formed by the pre-maxillary bones, the maxillary bones being placed behind them in a parallel position.

There are no pectoral or ventral fins, and all the vertical fins are reduced to little more than membranous folds. There is no air-bladder, and there are no pyloric appendages to the stomach. All these fishes are found in tropical regions; the first group, Amphipnoina, is formed for the Bengal species Amphipnous cuchia. It has the vent in the posterior half of the fish's length, and is covered with minute scales; the palatine teeth are in a single series, and there is an air-sac communicating with the gill-cavity. There are one hundred and six vertebræ in the abdomen and sixty-five in the tail. It is found in Bengal.

The second group, Symbranchina, includes the genera Symbranchus and Monopterus, both naked fishes, and neither possesses the accessory breathing sac. Monopterus is from the East Indies and Japan; Symbranchus has a species in tropical America and another in the East Indian region. The third group of the family, named from the typical genus, has but one species—Chilobranchus

dorsalis—a small fish, found in Australia and Tasmania. It has the vent in the anterior half of the body, the stomach is large, there are no teeth on the palate, and those on the jaws are in single series.

FAMILY XXVIII.—MURÆNIDÆ.

The Murænidæ are a large group of fishes, presenting no small amount of variation in the details of their structure. The long body is sometimes cylindrical and sometimes compressed like a band. In certain genera it is naked, in others defended with rudimentary scales. Both maxillary and pre-maxillary bones carry the teeth in the upper side of each jaw, and the ventral fins are always absent. Dr. Günther groups the genera into two sections, the first distinguished by the branchial openings into the pharynx being wide slits, while in the second group those slits are narrow. The former group is the more important, and includes the majority of the genera.

The first type in the family is the Nemichthys scolopacea, in which the body is band-shaped, and the tail exceedingly long and tapering to a point. The vent is near to the root of the pectoral fins, the jaws are elongated into a slender bill, the inner surface of which is covered with small teeth, which are little more than asperities.

The dorsal fin commences behind the head. This fish occurs in the Atlantic. A specimen thirty-three inches long has the head three inches long.

The second type has the tail longer than the trunk, the bones are thin, and the muscular system is moderately developed. It is represented by the single species Saccopharynx flagellum, which Dr. Günther describes as a deep-sea Conger Eel. The snout is very short and the gape immense. The stomach is capable of being distended to an amazing extent; the vent is at the extremity of the trunk. This fish is known from Madeira and adjacent parts of the Atlantic. It is perfectly black, and reaches a length of about nine feet, the greater part of which is formed by the tail.

The third type is furnished by Synaphobranchus pinnatus, a deep-sea fish from Madeira, with a scaly body, wide gapc, extensible stomach, and well-developed fins.

The fourth type is characterised by having a fin surrounding the end of the tail. It includes such genera as Anguilla, Conger, Congromuræna, and Uroconger.

In the genus Anguilla, or true Eels, small scales are imbedded in the skin, the teeth are arranged in bands, and the dorsal fin does not extend forward to the back of the head. The Eels range all over the world, except into the Arctic regions. The Anguilla Bengalensis extends through the rivers of the Indian Continent; the Fiji Islands contribute a peculiar species from three to four feet long; the north-east of Australia, and the Zambesi, Amboyna, the Seychelles, and many other localities have their characteristic forms; while others, like the Anguilla australis, range over a wide area, as from New Zealand to Timor, or, like the Anguilla bostoniensis, range from Boston to China and Formosa. The best known of the Eels is the common European species.

THE SHARP-NOSED EEL.*

The ordinary weight of a large Eel is about four pounds, but examples have been caught in the Medway weighing as much as from thirty-five to forty pounds, and measuring six feet in length. Couch, indeed, instances a printed record of an Eel that weighed sixty-two pounds, but confesses his doubts as to the statement being trustworthy. The form of the Eel is very similar to that of a Snake. The fish inhabits most of the rivers, ponds, and lakes in this country, and especially abounds in the Cambridgeshire fens, where in monastic times it was often a principal item of food. Eels for the London market are largely imported from Holland. The common Eel has been kept in confinement for at least thirty years; it lies torpid in the winter, and though it may move on the bottom during fine days, takes no food. They eat but little in the spring, but as soon as the warm weather begins develop an almost insatiable appetite, subsisting chiefly on worms. They become quite tame, and take food from the hand. Towards autumn, they often leave the water, but by the beginning of September retreat to their winter resting places under the stones. When in the rivers, the adult Eels make an autumn migration, probably for the purpose of depositing the spawn, but it is uncertain whether they go merely into brackish water or far out to sea. There is also a spring migration, and most writers concur in stating that at this time the young Eels travel up the streams. During the cold part

* *Anguilla vulgaris.*

of the year Eels frequently bury themselves in the mud, sometimes to the depth of a foot or more, and on the banks of many rivers they are easily dug out when in this torpid condition. Eels are highly excited and restless during electrical disturbances in the air. Yarrell states that though absent from cold countries, they may remain on the ground till frozen, be buried in the snow for days, and then recover perfectly when put back into water. The spawning has never been observed. They sometimes attack other fishes, especially the Carp, and consume immense quantities of spawn and fry, and when no other food is available will eat each other. Rats and Snakes have been found in their stomachs. The vent includes four distinct openings, two of which are for the discharge of the roe. The air-bladder tapers at each end, and has two short branches in front. The lower process, like the posterior extremity of the air-bladder, is cellular, and the bladder also contains several transverse partitions. In the tail there is a pulsating lymphatic heart, similar to those which have been described in Frogs and other Amphibia. Examples of this Eel have been found in the Nile, Palestine, Algiers, Madeira, in the Mediterranean, and in North America.

THE BROAD-NOSED EEL.*

This species is even more widely distributed than the Sharp-nosed Eel, since it occurs throughout Europe, in the West Indies, New Zealand, China, and the Nile. It presents many slight varieties, and is characterised by the broad and fleshy lips and the comparatively wide head. This Eel is sometimes called the Grig. It rarely weighs more than five pounds, but is thicker in proportion to the length than the Sharp-nosed Eel, and is said to give a more greasy sensation to the hand. It has no peculiar habits. These two species are the only European Eels.

THE CONGER EEL.†

The Conger Eel has no scales; the mouth is wide, and the teeth are arranged in rows, one of which is so closely packed as to form a sharp cutting edge. The vomerine teeth reach backward nearly to the tip of the tongue. The biting power of the fish is extraordinary, for Yarrell mentions that he has found in the stomach the finely-comminuted shells of Mollusca; but they do not always divide their prey, for in the stomach of a large fish a young Conger was found, three feet long, in company with some Dabs. Congers grow to a large size, and may reach a length of ten feet and a weight of a hundred and thirty pounds. The flesh is chiefly eaten by the poor, but when dried and grated it is made into excellent soup.

In Cornwall, where they are most abundant, the fish is usually taken on dark nights, on short or long lines baited with the Pilchard. They often live among rocks; those from such positions are uniformly black, while in sandy places they may be white or ash-coloured. Among the odd contents of the stomach, Couch records Soles and Plaice, Skulpins and Weevers, Lobsters, Hake, Pilchards, Herrings, and Cuttles. Their digestion is so rapid that when a hook is swallowed it is soon dissolved. One of the most singular habits of the fish results from the prehensile power of the extremity of the tail, which is capable of being used like a hand, for it has often been known to grasp the gunwale of a boat with it and leap over into the sea. A habit no less remarkable is its power of rapid rotation about its own axis, which has been exercised upon incautious thumbs and toes which fishermen have inserted into its mouth. The fish is sensitive to cold and to east winds. It is met with between the shore and a depth of fifty fathoms. The colour is usually pale brown above and dull white on the belly, with a white lateral line. The dorsal fin begins opposite to the extremity of the pectoral fin. The skeleton is distinguished from that of the common Eel by the longer transverse processes, which extend down the tail, but in the genus Anguilla transverse processes are wanting in that position. It is found round the coasts of Europe, in the Mediterranean, South America, Tasmania, East Indian Archipelago, and Japan. It spawns in December or January.

The fifth type of this family includes scaleless Eels of the genus Heteroconger, which have the tail compressed, the snout short, the lower jaw projecting beyond the upper, and no pectoral fins.

The sixth group has for its type the genus Muræsenox, in which the jaws have canine teeth. The species are found in tropical seas, chiefly in the East and West Indies. The allied genus, Nettastoma, is from the Mediterranean and Japan.

* *Anguilla latirostris.*

† *Conger vulgaris.*

The type of the seventh group is the genus Myrus, in which the nostrils are upon the margin of the upper lip, and the tongue is fixed as in the preceding group.

In the genus Murænichthys the body is long and worm-like, and without pectoral fins. The species frequent the Indian Archipelago.

The eighth group chiefly comprises the species of the genus Ophichthys, which are very numerous. The nostrils are placed as in the last group, but the extremity of the tail is not surrounded by fins. In some of the species, such as Ophichthys quadratus, from China, the tail is four-sided, and the dorsal and anal fins are absent. The pectoral fins present all degrees of development; the teeth, too, are very variable, and in some species, like Ophichthys boro, they are granular. This species occurs in both the

THE CONGER EEL.

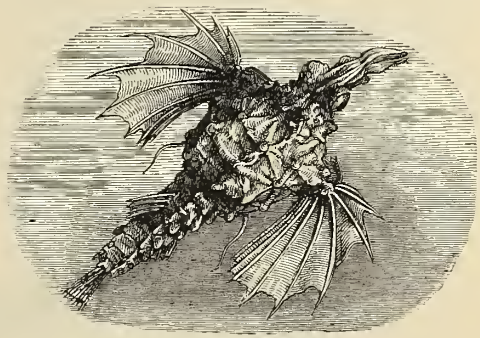
fresh waters and seas of the East Indies, and apparently has been met with in the West Indies also. Other species have the lips fringed.

The ninth group comprises the genus Moringua. It has the tail much shorter than the trunk, and the heart situated far behind the gills, and as in so many of the Eels the gill-openings are narrow and on the under side. The species occur in the East Indian Islands, but range to Japan. There are about ninety vertebræ in the body and forty in the tail.

The tenth group has the genus Muræna for its type. It contains a very large number of species, which are all without scales and have no pectoral fins. The teeth vary a good deal with age, as the series are more numerous in the young than in the adult. In a good many forms the teeth are sharp, in others, feeding on crustacea, they are blunt and have the character of grinders. Some species have the posterior nostrils tubular. The ornamentation may consist of spots, which are brown or black, round or polygonal. Sometimes there are black cross-bands, while other species are ornamented with a network of yellowish lines. The Muræna macrurus, which reaches a length of fully ten feet, has the tail twice as long as the body. The Muræna Richardsonii, another Indian type, has the skin folded, with the folds crossing each other so as to form pouches. The Muræna undulata is incapable of completely shutting its mouth.

The orbit in this genus is generally formed by a complete bony ring. Certain fishes have been described under the name Leptocephalus, which Dr. Günther regards as larval forms, for they have the notochord unossified and the eye large, and other evidences of imperfect development. It would hence appear as though some of the Congers passed through a sort of metamorphosis, and this condition may characterise the genera Myrus, Ophichthys, and Muræna. In these fishes there is never any trace of reproductive organs, no air-bladder, the vent cannot always be discovered, the stomach has a large blind sac, and the straight intestine runs close to the abdominal surface. When any ossifications occur they are always towards the end of the vertebral column. There are no ribs; the skull is cartilaginous; but both jaw-bones sometimes contain a little bony matter. Gelatinous substance usually occurs between the muscles and the notochord, and the same substance divides the lateral muscles from each other. The forms with a cylindrical body have red blood, but those with a flat body have the blood but faintly coloured.

FAMILY XXIX.—PEGASIDÆ.



THE PEGASUS DRACONIS.

This family is represented by the one genus Pegasus, a group of small sea-fishes from the Indian and Australian seas. It may belong to the Acanthopterygii, for the body is entirely covered with bony plates, which are blended together on the trunk, but form rings on the tail, and they resemble the Cataphracti in this and other characters. The plates on the tail are movable. The gill-cover is a large plate formed of the opercular bones blended together, though the inter-opeculum is a delicate bone lying below it. The snout is greatly elongated; the mouth is toothless. The bony ring below the eye is well developed. The vertebræ are thin, and there are no ribs. The pectoral and ventral fins, Dr. Günther remarks, have more of the Acanthopterygian than Physostomatous character. They are from India, China, and the Australian coasts.

DIVISION III.—CYCLOSTOMATA * (FISHES WITH A CIRCULAR MOUTH).

The third great division of fishes is a small one, much lower in organisation than the groups which have been already described, and belonging to an altogether distinct type. The vertebral column is represented by a notochord, upon which the skull is not movable. The whole skeleton is cartilaginous, and there are neither ribs, jaws, nor limbs. The mouth is margined by a circular lip, and is suctorial. The intestine is straight, without appendages of any kind. The form of the gills has suggested the name Marsipobranchii for this order of fishes, for they are purse-like organs, with a number of lateral apertures which somewhat resemble the gill-openings of Sharks, except that they are usually small and more or less circular. The heart is formed on the plan usual in fishes, but the *bulbus arteriosus* was long overlooked, and its existence is sometimes denied. The brain is small and fish-like, and quite distinct from the spinal cord. The nostril is a single tube in the middle line of the head.

ORDER MARSIPOBRANCHII.†

FAMILY I.—PETROMYZONTIDÆ.

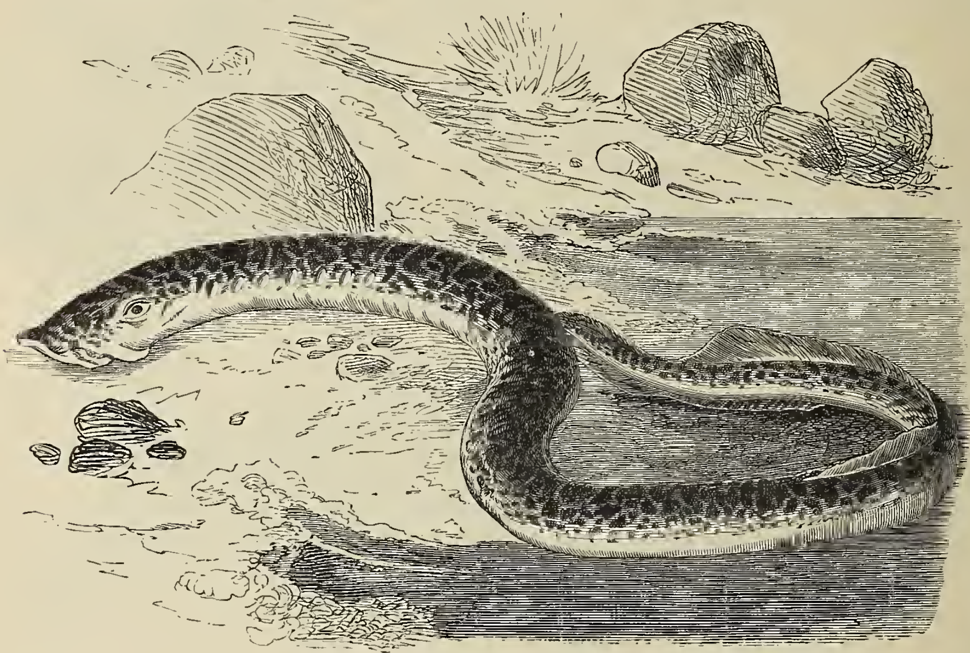
The fishes of this family are commonly known as Lampreys. They have the body shaped like that of an Eel, are naked, and undergo a sort of metamorphosis. The larval form was long supposed to be a distinct fish, and named Ammocoetes. The head is then very small, the upper lip is semicircular, and the lower lip, which is separate, is small, and the mouth is toothless and surrounded by fringed barbels; the eye is small and hidden in a groove. The vertical fins extend round the body as a continuous fringe. It is not till the third or the fourth year that the fishes undergo the

* *kuklos*, circle; *stoma*, mouth. † *marsipos*, pouch; *branchia*, gills.

metamorphosis and attain complete development. In the adult, as in the young, there is only a single nostril on the upper side of the head. There are seven branchial sacs. The intestine has a spiral valve.

THE SEA LAMPREY.*

The Sea Lamprey commonly attaches itself by the mouth to stones and rocks. The mouth is full of small teeth. The maxillary teeth are two in number and united together; in the lower jaw there is a single crescent-shaped tooth-plate, with from seven to nine cusps. The other teeth are arranged in rows, which cross each other obliquely, and more or less cover the whole surface of the mouth and throat; some of them are bicuspid. They often attach themselves to the bottom of a boat or ship, and the air is so perfectly exhausted that a fisherman is sometimes unable by sheer strength to pull the fish off. Couch records that the young Lamprey often attaches itself to the Mackerel, Gurnard, Coal-fish, Cod, and Haddock, rasping considerable holes in the flesh with its suctorial teeth, and he states that



THE SEA LAMPREY.

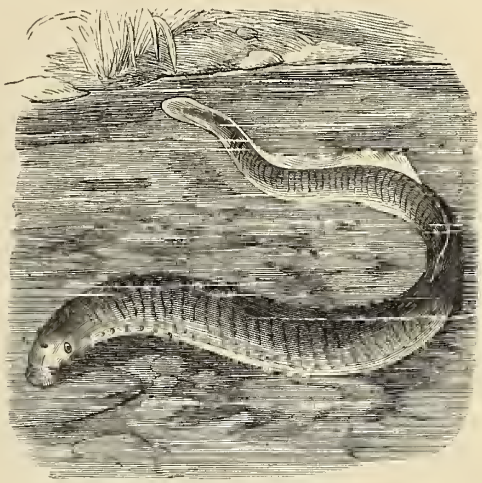
instances have come under his notice in which wounds evidently made in this way have afterwards healed. The spawning time of the Sea Lamprey varies a little in different countries, but in England the spawn is deposited in April and May, when the fish ascend rivers. They are then in the finest condition, and are caught at night. The male and female fish prepare a groove in the bottom of the river, in which the eggs are placed so as to be covered with sand. Yarrell states that the roe escapes by a membranous sheath, the internal face of which has five apertures. The fish has always been valued for food. In this country it is chiefly taken in the Severn, though sometimes met with in the Thames and many other rivers. It is found in the Rhine as far up as Basle, in nearly all the rivers of France, in the Rhone, and the Italian rivers which empty into the Adriatic and the Mediterranean. According to Siebold, it occurs on all the coasts of Europe excepting those of the Black Sea. It ranges southward to the west coast of Africa, and is found in North America. The Sea Lamprey usually measures less than three feet in length.

The first dorsal fin is well separated from the second dorsal fin. Both are placed on the hinder part of the body. The colour is a greenish-brown, marbled on the sides and back with darker tints of brown and green. It swims with lateral movements of the body, but commonly remains on the bottom. The mouth shuts laterally instead of vertically.

* *Petromyzon marinus.*

THE LAMPERN, OR RIVER LAMPREY (*Petromyzon fluviatilis*).

In the River Lamprey the skull is cartilaginous below, and in front carries a considerable mass of labial cartilages. The neural arches may be represented by cartilages. The maxillary tooth has a broad base with a cusp at each extremity, and the mandibular tooth is a corresponding plate with seven to nine cusps, which are relatively smaller than in the Sea Lamprey. It is a much smaller fish than the latter, and is commonly from a foot to fifteen inches long. It lives on insects, worms, and small fishes. It abounds in the Thames, from which formerly a million Lampreys were taken in a year. It is met with in the Severn, and has a wide distribution in the rivers of Europe, and occurs in some of the lakes of North Italy. It is also found in North America and Japan. The ovaries, according to Heckel and Kner, extend the entire length of the abdomen. The intestine does not enlarge into a true stomach. This fish is chiefly valued for bait, being tenacious of life, so that it can be kept alive at sea for some weeks. It is sold at from £3 to £5 a thousand. When pickled, it is imported from Holland for the German inhabitants of Soho. The colour is dark bluish on the back and silvery on the sides.



THE RIVER LAMPREY.

THE SAND-PIPER (*Petromyzon branchialis*).

This species is often called the Fringe-lipped Lamprey, because the circular lip is furnished with numerous papillæ. It is shorter and relatively thicker than the River Lamprey. Its teeth are much blunter, but otherwise similar to those of Petromyzon fluviatilis. The dorsal fins are deeper, but separated by a notch. It is common in the rivers of Europe and our own country, and occurs in the western parts of North America. Its habits are very similar to those of the other fresh-water species, which it resembles in colour.

The young of this species is sometimes called the Mud Lamprey, or " Stone-grig." The upper lip is then remarkable for its horseshoe shape; the mouth is incapable of adhering to stones. The fish hides in the mud and loose sand at the bottom of brooks. It is said to be devoured in great numbers by the Eel. The eggs are hatched in eighteen days, when the young fish are white. At first there are eight branchial slits, but the front one soon disappears. Before the mouth comes into existence there is an oval vesicle in its place, and there is no separation in the young between the alimentary canal and the branchial organ. The respiratory canal is usually not completed till the end of the fourth year, when the metamorphosis takes place, occupying a period of about ten days. The teeth then develop, the intestine becomes shorter, the eyes become more perfect, and the Lamprey's food is changed from microscopic organisms to such animals as have been mentioned. With the shortening of the intestine the body itself shortens, so that the mature fish is often smaller than the immature form. Having become a Lamprey, it puts on a silvery appearance and moves into clear water. It is probable that having reached the perfect state it spawns but once. No other fish presents so remarkable a transformation.

Other species of the genus are found in British Columbia and in Buenos Ayres. One or two allied genera have a curious geographical distribution. The Geotria chilensis, a species about two feet long, which has a pair of long, pointed, lingual teeth, compared by Dr. Günther to the horns of a young Antelope, is found in New Zealand, the Swan River of Australia, and in Chili. The Mordacia mordax occurs in Chili and Tasmania, and has two pairs of serrated teeth on the tongue.

FAMILY II.—MYXINIDÆ.

The Myxinoids closely resemble the Lampreys in having a naked Eel-shaped body; the nostril similarly has a single aperture at the extremity of the head, but, unlike that of the Lampreys, the nasal

duct is not lined with cartilaginous rings in the manner of trachea. This duct opens by valvular apertures on the roof of the mouth. Professor Owen, however, regards this organ rather as representing the spiracles of Sharks, which run from the top of the head to the sides of the branchial chamber. There are barbels on the head, the mouth has no lips, there is one tooth on the palate, and two teeth like small combs on the tongue. The branchial apertures are far removed from the head; mucous sacs extend all along each side of the abdomen. The intestine in these fishes, unlike that of the Lampreys, has no spiral valve. The eggs, too, are relatively large, and are contained in horny cases provided with short filaments, by which they become attached.

THE HAG.*

The vertebral column in this fish consists of soft substance, showing scarcely any trace of division into vertebral rings, the cartilage surrounding the semi-fluid primitive notochord. The usual length is about a foot; the body is compressed behind; the snout is conical, but rather blunt; the caudal fin reaches forward to the vent; its rays are numerous. There is another fin between the vent and the gill-openings which contains short stout rays. The lateral line contains more than a hundred glands, which form a bead-like chain along the body, and from these the mucus is poured out, which has suggested the specific name of the fish. Water enters by the nasal tube, so as to supply the gills; and in this respect cyclostomous fishes form an exception to the general law that the nostril has no respiratory function in fishes. The only other fishes in which the nostril opens on the palate are the Dipnoi.† At the back of the gullet in the Hag are six small tubes communicating with the sacs which replace the ordinary gills of fishes, and from these gills are passages which unite on each side into a single tube, opening on the belly, at about a third of the length of the animal from its mouth. The portal vein in this fish has a rhythmic contraction. The quantity of slime secreted from the body is prodigious. Couch mentions that a single individual placed in three or four cubic feet of water filled it so completely with the mucous secretion that the entire mass could be lifted out with a stick in a continuous sheet; and hence some of the older naturalists believed this fish had the power of converting water into glue. The eggs are large and yellow; no more than twelve have been found at one time in a developed state in the ovary. The ovary is placed below the notochord, and consists of plates. The fish is remarkably sluggish, but when it moves swims like an Eel. It frequents muddy ground, and lives in deep water. It is rarely captured, and never approaches the shore. It extends along the coasts of Europe and North America, but is chiefly known from northern waters. The mode in which this animal feeds is one of the most singular facts of natural history, since it enters by the natural apertures into the bodies of Mackerel and various fishes of the Cod family, and devours not only the intestines but often the flesh also. Sometimes the fisherman draws up on his line a Haddock, of which nothing remains but the bones and skin. This destruction is sometimes accomplished by a single Hag, but as many as twenty have been found in the body of a single fish. The Hag has occasionally been found partly digested in the stomach of a Cod. Another species is found in the temperate parts of the Pacific coast of South America.

The genus Bdellostoma, with a general resemblance to the Hag, has many branchial apertures on the sides of the body, each of which leads by a separate duct to a gill or branchial sac.

In the Bdellostoma cirratum, found at the Cape of Good Hope and New Zealand, there are six or seven of these gill-openings on each side, but in the Bdellostoma polytrema, from the coast of Chili, there are fourteen openings for the gills extending along each side of the abdomen. Thus in external appearance this fish presents some resemblance to the yet lower Amphioxus, which is the last and most degraded member of the fish class that is known.

* *Myxine glutinosa.*

† The following sentence was omitted from the account of the Mud-fish on p. 20, and should be added to the paragraph containing a statement of Professor Owen's opinion:—"Subsequent researches, especially those of Professor Huxley, have demonstrated that the nasal sacs of Lepidosiren open on the inside of the upper lip, so as to form true posterior nares; but this correction does not affect the general truths of Professor Owen's generalisation as to the closed nasal sac being a distinctive character of fishes."

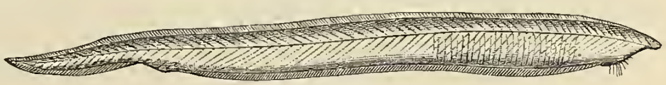
The figure of a Codfish skull on page 5 has the supra-occipital bone on the upper right-hand corner indicated by the letters *s.o.* instead of *s.*

DIVISION IV.—LEPTOCARDII * (FISHES WITH THIN HEARTS). ORDER PHARYNGOBRANCHII.

This concluding group of the fish class contains only two species—

FAMILY CIRROSTOMI.—THE LANCELET.†

This little fish is never more than three inches long, is transparent and iridescent, is very active, and has a fin extending from near the snout round the tail to the vent. The body is compressed, the head pointed; the eye is a dark speck in a slight depression of the skin; the mouth is an elongated oval, placed longitudinally and margined by slender filaments, which are ciliated and supported by a cartilaginous framework, which extends round the mouth. Behind the mouth is the pharynx, which is perforated by numerous vertical or slightly oblique branchial clefts, which extend far down the length of the body. Behind the pharynx is a simple stomach prolonged into a straight intestine, which terminates in a vent near the root of the tail. There is another aperture in front of the vent, which opens into a cavity distinct from the pharynx, which extends forward towards the mouth. The function of this pore appears to be to carry off the water, which, propelled inward to the pharynx by the mouth, passes through the branchial slits into the external cavity. In an early stage of development the branchial slits are entirely exposed on the sides of the body. There are no gills. The liver is an appendage to the intestine. The reproductive organs are glandular masses, arranged in a row along each wall of the body cavity. The heart has no trace of the muscular character seen in the higher Vertebrata, which have hence been distinguished from the Amphioxus as Pachycardii, while the name Leptocardii indicates the thin wall which is here seen in that organ. In fact, the heart is no more developed than is the heart of a chick when it first appears in the first few days of incubation. Contractions take place only at the rate of about one a minute. All the principal blood-vessels are contractile. The blood is quite colourless, and, as in the lower animals and the young of Vertebrata, the blood-corpuscles are nucleated, so that the red corpuscles have not as yet been formed. The skeleton is very imperfectly developed, and, beyond that part already referred to, around the mouth is limited to a notochord, which shows no trace of transverse division into vertebræ or of superior or inferior arches or ribs. It extends some distance in front of the spinal cord. There is therefore no skull or brain in any ordinary sense of the term, and the anterior extremity of the spinal cord, instead of enlarging, diminishes in size; it gives off nerves to the eye and the filaments round the oral region. The fish displays many analogies with the invertebrate group termed Ascidians, and somewhat resembles amphibians in the mode of formation of the cavity external to the branchial slits. The surface of the body is smooth and entirely destitute of scales. When first studied the Lancelet was mistaken for a slug, just as the Hag was mistaken for a worm. It has been kept in captivity, and observed to usually bury itself a little in the sand when disturbed. It is extremely sensitive to light; it often lies as though dead for half an hour or an hour together. This fish can scarcely claim to belong to the Vertebrata; it wants many of the more striking characteristics of fishes, and certain observers have sometimes surmised that it may possibly be an embryonic fish of which the mature form is unknown. This, however, is unlikely. But it differs from other fishes in characters in which they all agree, and differs also from fishes in points of structure which are common to them and higher Vertebrates. It might well form the type of a class standing alone, and helping by its low grade of organisation to indicate one of the lost steps of continuity between vertebrate and invertebrate animals. It frequents shallow water, and is widely distributed in temperate and tropical seas. A second species has been found in Moreton Bay.



THE LANCELET.

FOSSIL FISHES.

A large proportion of fossil fishes belong to the division Palæichthyes. This group comprises most of the fishes which have been met with in the primary rocks and many of those found in the

* *Leptos*, thin; *cardia*, heart. † *Amphioxus lanceolatus*.

Secondary strata: but in Tertiary deposits the Teleostean division is quite as well represented in the geological formations as in existing seas. There is no evidence of any gradual succession of fishes in the order of increased complexity of structure, as the deposits in which they occur approach nearer to the present day. And there is no reason to suppose that the oldest fishes known were the first that appeared upon the earth. The earliest fishes discovered are met with in the lower Ludlow rocks, which form the upper part of the Silurian strata. The most ancient genus is Scaphaspis, a small buckler-headed fish, which had the body covered with scales. Many allied genera are found in the overlying Old Red Sandstone, in which fishes appear in extraordinary variety. Among the allies of Scaphaspis are Pteraspis, Cephalaspis, Auchenaspis, and Didymaspis, some of which range down to the Silurian rocks. Near to these fishes must be placed Coccosteus, Pterichthys, and the immense American fossil of Devonian age, named Dinichthys. These fishes are thought to be related to Ganoids and Sharks, but in external form they more closely approximated to Loricaria, though the tail is heterocercal. They form a distinct group named Placodermi. Existing fishes, however, with heterocercal tails, have the tail homocercal in an embryonic stage of development.

The Ludlow bone-bed consists almost entirely of bones of fishes much triturated and matted together, and very few species of fishes have been recognised in it, but among them is a Shark-like fish spine referred to the cestraciont genus Onchus. The more striking of the Old Red Sandstone fishes belong to the group which Professor Huxley names Crossopterygidæ. This group of ganoids comprises many fossil families in addition to the living Polypterus. Among them are genera covered with rhomboidal scales, as in Polypterus, having two dorsal fins. The pectoral fins have the rays arranged round a long central scaly portion, so as to form a fringe. Osteolepis, Diplopterus, and Megalichthys are genera showing these characters. This tribe is named Sauro-dipterini. Another group, the Glyptodipterini, has sculptured scales, two dorsal fins, and the pectoral fins greatly elongated. Some of the genera, such as Glyptopomus, Glyptolæmus, and Gyroptychius, have the scales rhomboidal; but other genera, such as Holoptychius, Glyptolepis, Platygnathus, have the scales cycloidal, and to this group probably belong Rhizodus, Dendrodus, and other types. Another section formed for the genus Dipterus is termed Ctenodipterini. All its fins are elongated, and look like lobes of the body. Its scales are cycloidal, and the teeth are crossed by ridges. The genus Phaneropleuron, has one long undivided dorsal fin and thin cycloidal scales: its teeth are conical. The Cœlacanthini is another remarkable group of these fishes, which have the air-bladder large and ossified. It includes such forms as the Cœlacanthus and Macropoma, which latter ranges through the Kimmeridge Clay to the Chalk. A section of the Ganoid order, represented at the present day by Lepidosteus, appears in the Secondary strata to have attained an immense development; but while the living Lepidosteus has the maxillary bone divided into several pieces, the fossil genera of the Lias and other Secondary formations have the maxillary bone in one piece. Among the better-known fossil genera are such types as Lepidotus, Dapedius, Tetragonolepis, Eugnathus, Pachycormus, and Aspidorhynchus. The fishes allied to Pycnodus have the jaws covered with rows of flat-crowned teeth, adapted for crushing, with sharp incisor teeth in front. Pycnodus ranges through the Secondary rocks up to the Tertiary, a species being found in the London Clay of the Isle of Sheppey. Closely allied to these forms are genera, from the primary rocks, such as Platysomus, in which, as in the Palæoniscidæ, the vertebral axis is notochordal, the caudal fin is heterocercal, and the scales have the ganoid character. The fishes resembling Platysomus have a short and deep body, which is more or less ovate and rhomboidal in outline, while genera allied to Palæoniscus have the body much more elongated. The Acanthodini are fishes with small scales like shagreen. Each fin carries a strong bony spine in front. Chiracanthus and Acanthodes have a single dorsal fin, but Diplacanthus has two dorsal fins. These genera are chiefly found in the Old Red Sandstone. The Dipnoal fishes are represented in a fossil state by the Devonian genus Ctenodus, and Ceratodus, known from teeth in the Trias and lower Oolites. The Chimæroid order does not range further back in time than the Lias. It is represented by species of Ischyodus and Edaphodon in Secondary strata, and by the genus Elasmodus, which is only known from Tertiary deposits. Fossil Sturgeons from the Lias belong to the genus Chondrosteus; in the London Clay the Acipenser toliapicus is found. Of Sharks, the strata yield many remains, but they are chiefly known from teeth and the defences which support the fins. The slug-like teeth of Acrodus, Strophodus, and Ptychodus, in the Secondary

strata, are allied to the Cestracion, as are the teeth of Psammodus, Petalodus, and other genera found in the Carboniferous rocks. The grey Sharks are represented by species of Notidanus in both the Cretaceous and Tertiary rocks. The Porbeagle genus Lamma has many species in the same formations. The Skates are well known in a fossil state. A large number of the doubly-serrated spines, found in the coal measures, appear to belong to the Trygonidæ. Other types, like the Eagle Ray, are well represented by such genera as Zygobatis and Myliobatis. Fossil species of Torpedo are met with in the Tertiary deposit at Monte Bolca. Saw-fishes exist in the lower Tertiaries of the London and Hampshire basin.

The Teleostean fishes chiefly belong to the larger orders. Although the Teleostean fishes in an embryonic stage have the tail heterocercal, and afterwards grow through that into the homocercal stage, the fossils hitherto found afford no demonstration that Teleostean fishes have been evolved from the Palæichthyes. The Perch family is well represented in a fossil state, especially in the Tertiary formations of Monte Bolca and Œningen. The Sea Breams date back to the Cretaceous rocks of Mount Lebanon, and the family is well represented in the Lower Tertiary strata. The Scorpænidæ, a family remarkable for often possessing poison glands on the spines, is represented by a fossil species of Scorpæna from the Eocene of Algeria. Fishes allied to Beryx are known from the Cretaceous and Tertiary rocks of many parts of the world. The Sword-fishes first appear in the chalk of England. An extinct genus of this group is found in the London Clay. The family Trichiuridæ are well represented in the Secondary rocks, especially the Upper Greensand and Chalk, by the genus Enchodus, which has long strong teeth. In the Tertiary beds this family becomes more abundant, while several existing genera occur in the newer Tertiary strata. Closely resembling these fishes is the extinct genus Palæorhynchus, which has jaws forming a long beak; it is found in the slates of Glaris. The family Acronuridæ is represented in the deposits at Monte Bolca by fossil species of the living genera Acanthurus and Naseus. The carnivorous family Carangidæ date back to the Secondary period. The family Coryphænidæ has some Tertiary representatives chiefly from the Isle of Sheppey and Monte Bolca. The Mackerel family have only been found in the fossil state in Tertiary beds. Fishes allied to the Star-gazer have been met with in the newer Tertiary formations. The Gurnards are known from species of Trigla and a few other genera in beds of Tertiary age. Closely allied to the Flying Gurnards is the genus Petalopteryx, from the chalk of Mount Lebanon. The Gobies are found for the first time in the chalk, but extinct species of Gobius occur in the older Tertiaries. The family Sphyrænidæ are well known by such genera as Hypsodon and Portheus, in the chalk, while various other genera represent the group in Tertiary deposits. The Grey Mullets first appear in the Tertiaries of France. The Wrasses are represented in Tertiary rocks by the genus Egertonia from the London Clay of Sheppey, and by species of Labrus and other genera in the Lower and Middle Tertiaries of Switzerland. The fossil remains of Anacanthini are not abundant. Fishes allied to the Cod and Hake are found in the London Clay; other members of this group are found in newer Tertiary deposits. Flat-fishes, allied to the Turbot and Sole, occur at Monte Bolca. The order Physostomi has many fossil representatives. The family Scopelidæ is, perhaps, represented by Osmeroides in the chalk and by other genera in the Tertiaries. The Carps do not date farther back than the middle Tertiary deposits, being plentifully met with in the lignites of Germany. The Cyprinodontidæ are represented by species of the genus Cyprinodon in deposits of the same age. Fossil Pike are found in the fresh-water limestone of Œningen. The Salmon tribe is represented by several genera in the chalk. The Herrings are numerous in the upper Secondary rocks, though more abundant in the Tertiaries. And the Eels first appear in the older Tertiary formations. The Pipe-fishes do not appear before the Tertiary period, and in the same formation at Monte Bolca the Box-fish Ostracion occurs. Glyptocephalus, from the London Clay, is allied to the File-fish Balistes. Globe-fishes allied to Diodon are found fossil at Monte Bolca. Forms intermediate between Eels and Congers occur in the London Clay. The Lampreys have no parts likely to be preserved in a fossil state, unless some of the fossils called Conodonts, from the Primary rocks, are teeth belonging to this group.

In writing this article I have to acknowledge the obligations I am under to the various works of Dr. Günther, Yarrell, Couch, and Professor Owen.

H. G. Seeley.

THE ANIMALS WITHOUT BACKBONES—THE INVERTEBRATA.

INTRODUCTION.

Characteristics of Vertebrata—Modifications—Characteristics of the Invertebrata—Various Distinctions among Themselves—Habits—Classification—Intermediate Groups.

THE animals, whether mammals, birds, reptiles, amphibians, or fish which have been described or noticed hitherto in this work, have some parts of their construction which are similarly placed, and fashioned after one plan. They have a series of bones, or vertebræ, forming the spinal column, upon which the skull is placed; and these structures separate the brain and its continuation—the spinal cord—from the organs of digestion and respiration, and from the main organs of circulation.

These animals, which constitute the great group of the animal kingdom, is called the "Vertebrata." They have red blood, and in some classes it is warm, and in the reptiles, amphibians, and fish it is cold. They have an internal skeleton, and never more than two pairs of limbs, and these are modified to meet the wants of the different classes, and in some instances they are more or less defective. One side of the body has a general resemblance to the other, but different organs are found on opposite sides within, in relation to the digestion and circulation, so that there is, generally speaking, a bilateral symmetry. The development of the nervous system, and especially of the spinal cord, brain and large nerves, is considerable even in the fish, and is increasingly great in the amphibians, reptiles, birds, and mammals. The organs of special sense—seeing, hearing, smelling, and of the sense of touch—are highly developed for the most part, and their possessors lead, sooner or later, independent lives, and seek their food.

Taking the great Apes as the highest of the animals we have noticed, and the Amphioxus as the lowest, so far as the scale of construction is considered, they and the intermediate mammals, birds, reptiles, amphibians, and fish are linked together by possessing many similarly arranged structures. The mammals can be readily distinguished, but the simplest and lowest of them, the Monotremes, have many points of anatomical resemblance with the reptilia and birds. The birds are linked on to the reptilia of the past history of the globe, and the reptilia to the amphibia and fish. Moreover, these last are closely allied by kinds which have structural arrangements that can hardly be definitely said to be those of the amphibian or those of a fish. From the history of the past, it is gleaned that these great groups, so interestingly linked together in the chain of natural classification, began to be and appeared in the order of their present classificatory position. The fish and amphibia preceded the reptilia; birds came next, and then the lowest kind of mammal. Thus, by their possessing an internal skeleton, a backbone, a skull, and limb-bones; by their having the nervous and vegetative systems separated, the one near the back (*dorsal*) and the other ventral; by their classes being connected by many common structures and by their geological history, the Vertebrata are a remarkably distinct and recognisable group.

These general statements have only to be modified in a few instances. In some of the simplest Vertebrata, that is to say, in some whose construction is less elaborate than the others, the spinal column, with its succession of separate bones, is replaced by an elongated rod of cartilage which is flexible, and to which certain membranes adhere. One membrane is folded above the rod (in the swimming position of the fish Amphioxus, page 147), and envelops the spinal marrow, and two others extend in the opposite direction and form and bound the cavity which contains the viscera. This rod, or corda dorsalis, really supports the spinal nervous system, and separates, as in the other Vertebrata, the nervous and vegetative organs. It exists in the early unborn or embryonic state of all animals which have, when born, a series of jointed vertebræ forming a backbone, and it is probable that the first fish that lived on the globe had this corda dorsalis or notochord only.

In the Amphioxus there is no true brain-case, and the special senses of hearing and seeing are at their lowest ebb, the ear being deficient, and the single eye is a mere mass of pigment, placed on the nervous swelling at the fore part of the spinal marrow which represents the brain of other Vertebrates. There is, therefore, no brain in this creature, and were it not for the cartilaginous rod and the relative position of the nervous system and of the digestive and circulatory organs—the one above and the other below the rod—the animal could hardly be called one of the Vertebrata. It has colourless blood, it has no true jaws, and the mouth opens into a cavity which is used for the

purposes of digestion and of respiration. The heart proper does not exist, but there are large blood-vessels which are contractile and move the blood. It is the simplest animal amongst the Vertebrata.

All the animals which are about to be described are *invertebrata*, that is to say, they have no jointed, bony, or cartilaginous spinal column, with a brain-case, and limbs, whose bones are connected with the internal skeleton. Even the cartilaginous rod or notochord is not found in any of the adults. This absence of the support and case of the great nervous centres is the great distinction between the animals which may be roughly exemplified by the Cuttle-fish, the Oyster, the Ascidian, the Insect, the Worm, the Starfish, the Coral, and the Amœba; and the Beasts, Birds, Reptiles, Amphibians, and Fishes. It is a negative distinction, but it is, nevertheless, pregnant with interest, for it seems to establish one of the few great breaks in the continuity of nature. So far as adult and fully-grown forms are concerned, the break is perfect. But were the imperfect young (the embryos) of one group of the Invertebrata—the Tunicata—to be considered especially, it would be found that they have what may be called the rudiments of a notochord, but placed far back, however, in relation to a tail, and not having the relative position to the nervous system and vegetative organs which is noticed in the Vertebrata. It is also true that there is a great similarity between the minute structures of some Invertebrata and those of the higher animals.

The Invertebrata present almost every variety of shape. Some are without any definite form, and change their shape constantly; others have no distinct head; many have the body arranged in joints or segments, and one side of their body resembles the other, and their symmetry is then said to be bilateral. A great group have their structures arranged in a radiate manner like the Starfish, and many others have their head distinguishable from the body. Although no internal skeleton exists with its limbs, after the fashion of the Vertebrata, yet the body may have particles of carbonate of lime or silica here and there in it, and often arranged in beautiful geometric patterns: or a test or shell may cover part or the whole body, or be included within it as a kind of support. In many great groups an external armour of shell or of hard skin is perfect and very elaborate in its varieties of shape and ornamentation. Many have soft skins. Their methods of locomotion are sometimes in relation with the external hard structures, which consist of skin or dermal structures, more or less modified, and provided with mineral matter or a substance called chitine, but this is not always the case. Some move on the ground with a slimy kind of foot, like the snail and slug; the one is provided with a complete shell into which it can withdraw, and the other has but a small hard portion. Others crawl under stones, make their way in the earth, and move over the surface like worms, and have either a hard coat to their segments, or a perfectly soft and slimy one. Those which lead the life of the insect may have hard or soft bodies at some period of their lives, and may be provided with limbs of more than two pairs in number. In some the development of legs and limbs is so great that nearly every segment of the body has them on opposite sides, and the piercing, sucking, capturing, and masticating organs are really modified limbs, and are not like the jaws of the Vertebrata. Some move by articulated limbs like the Crab and the Beetle, others have a coronet of long fleshy tentacles covered with suckers around the head; wings may exist as in the Butterfly, and correspondingly useful expansions exist around the neck of the swimming Pteropods. But these have no internal skeleton, and the limbs, &c., are essentially skin structures.

A vast number of the Invertebrata have the body covered with minute and rapidly vibrating structures, visible only under the microscope, called cilia; some are long and others are short, and they move the body in the water with great velocity. Again, some groups of this great division are without these remarkable simple structures. There are members of this lower group of the animal kingdom which move by taking in water and ejecting it in an opposite direction as they swim in the water; and not a few live in the water, fresh or salt at one, and in the air at another, period of their lives, or air and water are a common home; many live on the surface, and others on the floor of the deep sea. A great number of kinds lead an independent and moving life in their early days, and then fix on to some substance, or on another and larger animal, and remain sedentary, and some of them are then absolutely fixed like the reef-building Corals and the Barnacles; some may be fixed or remain still by their weight like the Oyster, and others anchor by a set of threads like the Mussel. On the other hand, some kinds, such as the Jelly-fish, are free movers in the water at first, then they settle down and become fixed and grow unlike their parent, and finally develop young, which, as they

grow and lead a free life, return to the parental shape. In the caterpillar, which lives to eat, the chrysalis, which is stationary and quiescent, and the free-flying moth, which may never touch food, the metamorphosis is very complicated; in others it does not occur at all, the young being born the image of their parent. Now, in all these instances the covering differs at different periods of their life, and moulting of it is frequent. Beautiful hairs, scales, and other modifications of the skin occur, and the colour is often striking and changeable. On the other hand, a colourless body may exist furnished with slime cells. Again, in some of the groups the skin is modified into stinging organs, as in the Jelly-fish and Coral. Muscles are attached within to these outside structures, which are thus of as great importance to the Invertebrata as the skeleton is to the Vertebrata.

The breathing, whether in air, fresh or salt water, takes place by the action of the whole, or part of the whole skin, by parts of it which are arranged and ciliated like gills, or which are turned inwards, like sacs and tubes within the body. Either the process is simple, the air or the aërated water coming in inevitable contact with the skin and its modifications, or, as in the Insecta, the movements of the segments of the body expel and draw in air. The circulation is carried out by contractile vessels in the higher groups, but none of them have the simplest vertebrate heart, although that of Amphioxus is imitated to a certain extent. In some the current of blood can be reversed. A great number have no organs of circulation, the juices pouring from part to part in an almost plant-like manner. The colourless blood is often without any corpuscles. A system of water channels and spaces often exists. The nervous system may be greatly concentrated in the head, and it then is situated above and below the gullet, there being branches on either side. A long cord with swellings, or ganglia, passes from the brain along the inside of the lower or ventral side of the body in a vast number of genera. In others the nervous system is supplied to the principal organs and foot in an unsymmetrical and irregular manner, and in the lower groups, whose construction is simple, the nervous element is extremely difficult of demonstration, and may radiate from centres, pass round the body, giving off threads to special organs, or may merge here and there into muscular structures, there being nothing like a nervous centre. No structure comparable with voluntary nerve fibre within is visible in the simplest forms of the Invertebrata.

Some of the Invertebrata have organs of special sense faintly developed, in comparison with those of the Vertebrata. Simple and compound eyes, or mere spots of pigment in contact with nerve, are common, but many groups are without any special structures by which light can be distinguished, although the influence of it is evident enough on their bodies. In one group the eye is internal and useless during a part of their life. Rudimentary but most useful organs of hearing exist in some; tactile nerve is exceedingly delicate in many; and a knowledge of the presence of food, or of substances, which give an impression of disgust to man, is evident enough in so many kinds, that something analogous to the sense of smelling must be present in them.

Many Invertebrata exist in very cold water, others live in warm brine springs, some require the purest air or the purest water, whilst not a few—which are parasites—live in impure situations. The intelligence and constructive acts of many Invertebrata are as evident as the simple, mechanical, and automatic lives of others; and it does not appear that it is possible to connect the highest intelligence with the highest development of the body generally in any scheme of classification. Moreover, the kind of intelligence differs in the different phases of the lives of many of the Invertebrata. There are many instances in which care is taken of the young by the parent or by the community, but in the majority this is not the case.

The methods by which the Invertebrata increase and multiply are numerous and extraordinary. Spontaneous division of the body, in one or more pieces, each becoming a separate animal; separation of the tissue of the whole creature into a vast number of minute microscopic globules, which burst forth and grow into the parent shape; separation of little pieces from the outside or inside, and these becoming independent; a process resembling internal building; the formation of living young within the body, and which pass forth not in the egg, but resembling the parent; and the laying of eggs, are the commonest. But the results of the egg laying are as extraordinary as the other methods. Some eggs are produced by virgin mothers, and in the hatching of all eggs there is a process of evolution within the egg envelope or shell. Most young thus produced do not resemble the matured parent, and pass through different stages of existence and shape before attaining maturity; and whilst

some advance in complexity of structure, others positively retrograde. A great number of kinds of several groups of the Invertebrata live the lives of parasites on or within other animals, and the great differences in shape and gifts which are noticed in the life cycle of these creatures are in relation to this fact. Some positively exist on the juices of their unwilling host, others are so placed that they help themselves to the food of their fellow-feeder, or to the supply set apart for its offspring.

The great division of the Animal Kingdom whose members have these characters cannot be classified as simply as the Vertebrata. The range of structural peculiarities is vast from the shapeless microscopic entity, which can only be separated arbitrarily from the lowest and simplest plant to the great Cuttle-fish. It does not appear possible to arrange the groups of the division in an ascending series by the nature of their nervous and other structural developments or intelligence, but several are on a level, as it were. Again, the history of the past does not assist us in explaining the succession of the Invertebrata on the globe, for in the oldest rocks, which afford evidence of a satisfactory nature, the highest amongst the Invertebrata are represented.

The classification, which is as natural as is possible under the circumstances of existing knowledge, but which, nevertheless, is very artificial, is as follows:—

The Invertebrata are divided into great types, or groups.

1. *The Mollusca.*—These are animals with a soft body, without segments, naked or covered with a shell of one or two valves composed of carbonate of lime, secreted by a fold of the skin—the mantle. They have a brain mass, and foot and mantle ganglia. Some have an internal hard shell, or cartilage. The symmetry of the body is bilateral. Example, Cuttle-fish.

2. *The Arthropoda.*—The body is in ringed segments of various shapes, provided with limbs; the brain is united to a ganglionic cord, which passes along the ventral surface within. The symmetry is bilateral. Example, the Common Fly.

3. *The Vermes.*—The body is either without segments, or may be composed of nearly similar segments, without articulated limbs. The symmetry is bilateral. Example, the Earth-worm.

4. *The Echinodermata.*—The body, or part of it, is arranged in a radial manner, the divisions being generally five in number. The skin contains or is covered by a symmetrical armour of plates of carbonate of lime. The digestive and circulatory organs are distinct and separate. There is a nervous system, and locomotion proceeds by ambulant tentacles. Example, the Sea Urchin.

5. *The Zoophyta.*—The body is arranged in a radial manner in divisions of four or six, or their multiples. A visceral cavity serves for digestion and circulation. Examples, the Coral and the Jelly-fish.

6. *Protozoa.*—Minute animals, with very simple organisation; structures, slightly differentiated; often unicellular. Example, Animalcules and Sponges.

These great divisions are not exactly defined in nature, and they are subdivided into secondary groups, and are also united in some instances by forms of life which cannot well be placed in any particular one.

INTERMEDIATE GROUPS.

1. *The Tunicata* have a more or less leathery or cartilaginous covering sac, which is more or less tub-shaped; a gullet with perforations leading to a respiratory cavity, surrounded by an inner skin, which envelops the viscera also. There is a simple nervous ganglion placed dorsally, and a rudimentary heart. The symmetry is to a certain extent bilateral. They may be placed in the neighbourhood of the Vermes and Mollusca in their classification. Example, the Ascidian.

2. *The Molluscoida* have the body with shells placed differently to those of the Mollusca, or have a tubular or shell-like covering. The gills are more or less free and fringed with cilia, without the usual lamellæ of the Mollusca, and they serve the process of the capture of food as well as of respiration, or there may be a crown of ciliated tentacles. *The Bryozoa* and *the Lampshells*, or *Brachiopoda*, are included in this group, and in their structures, embryonic and adult, they show resemblance to those of Vermes, Mollusca, and Tunicata.

These types or great groups are subdivided into classes, orders, families, genera, and species, which will be indicated in the description of their natural history.—Editor.

INVERTEBRATA.—TYPE MOLLUSCA.

CHAPTER I.

THE CEPHALOPODA.

Cephalopoda—Derivation of the Term—Unexpected Relationships—Shells—Utility of Aquaria—General Characters of the "Naked" Cephalopods—Classification: the Dibranchiata and Tetrabranchiata—Their Mode of Locomotion—The Mouth and Eyes—Means of Escape and Defence—Representative Dibranchiates in the Ancient World—DIBRANCHIATA, OCTOPODA—ARGONAUTIDÆ—The Argonaut, or Paper Nautilus—Its Fabled Position—Its Praises as Sung by the Poets—How the Nautilus really Swims—The True Uses of the Arms—Curious Fact regarding the Shell—The Male as Compared with the Female—The "Hectocotylus"—Species of Argonaut—OCTOPODIDÆ—The Common Octopus—Appearance—Formidable Seizing Organs—Owen's Description of the Tentacles—Mechanism of the Suckers—The Octopods of Leghorn—The Octopus of the Greeks—Mr. Darwin's Account of the Octopus—A Diver Attacked—The Adventures of an Octopus in an Aquarium—Spawning Season—Eggs of the Octopus—Henry Lee's Observations as to the Hatching of the Eggs—The Baby Octopus—New Growth of Amputated Limbs—Food for Predatory Fishes—Contests with the Conger Eel—The "Devil-fish" and Nursehound—Various Species of Octopus—De Montfort's Gigantic Octopus—Cuttles and Octopus as Diet—Octopus Fishery—DECAPODA—TEUTHIDÆ—Distinctive Features—The Tentacles—Suckers—Shell—Remarkable Skin Characters—Play of Colours—THE COMMON SQUID—"Pen-and-ink Fish"—Their Spawn—The "Little Squids"—The Nerve-masses of the Dibranchiata—A Tom Thumb Cephalopod—*Loligopsis*—*Cheiroteuthis*—*Histioteuthis*—The Clawed Calamary—Construction of the Suckers of the Calamary—The Armed Calamary—The Sagittated Calamary—"Sea-arrows"—Squid-bait—The Cod-fishery—Squid-jigging—The Giant Cephalopods—Instances of their being Met with, and of their Capture—Sir Francis Chantrey and Fossil Ink—BELEMNITIDÆ—No Living Representative—What the Fossil really is—Species—SEPIADÆ—The Common Cuttle-fish—Beautiful Coloration—The Bone or Shell—The Cranial Cartilage in the Cuttle—The Heart—Movements in the Water—Not Long-lived in Confinement, and why—The Cuttle's Eye—The "Ink-bag"—Discharge of the Ink—Use of the Ink—The Eggs of the Cuttle—Young Cuttles—Uses of the "Bone"—Various Species of Sepia—The Cuttle as an Article of Diet—SPIRULIDÆ—Genus Spirula—Remarkable Characters—Rarity—Difficulty of Studying it—Peculiar Shell Characters—ORDER TETRABRANCHIATA—NAUTILIADÆ—External-shelled Cephalopods—Nautilus and Spirula the only Siphonated Shells Living—Construction of the Shell—Rumphius's Account of the Pearly Nautilus—Mr. Moseley's Observations—How the Animal Moves—Abundance—Various Parts of the Nautilus—The Air-chambers—The Uses of the Siphuncle—Formation of the Septa—Fossil Members of the Tetrabranchiata.

CLASS I.—CEPHALOPODA.

ONE of the foremost groups in the Molluscan division or type of the Invertebrata is that of the class Cephalopoda*, so called by Cuvier, because the animals included in it have their feet or tentacles attached to the head, around the mouth, a simple and convenient arrangement for taking in food, and which we shall presently find repeated again in some other groups, such as the Stone Lilies and Sea Anemones, &c., nutrition being the highest ambition of the lives of at least a large majority of these animals.

The Octopus, or "devil-fish," the Cuttle-fish, and the Pearly Nautilus are excellent examples of these head-footed Mollusca, which (like the Sharks among existing fishes) represent at once a very ancient and singular group, but are nevertheless true Mollusca. The Garden Snail does not appear, on a cursory inspection, to have much in common with the "Sea Squid," or the "Cuttle-fish," but the Garden Snail is first cousin to the Slug, which has no visible shell, and the shell-less Octopus is next-of-kin to the Pearly Nautilus, which carries its shell upon its back.

Thanks to our public museums, we have long been familiar with those beautiful objects, *Shells;* and every schoolboy knows the look of the commoner forms of living Mollusca, such as Snails, Whelks, Mussels, Oysters, and Cockles, but it is only within the last few years that the introduction of Marine Aquaria in many of our large cities has made us really acquainted with sea-shells and their inhabitants in a living state. To these establishments we are more especially indebted for a knowledge of such forms as the Cuttle-fish and Octopus and their relatives, seldom seen upon our sea-shores, and of which we have first to speak.

By far the larger part of the existing members of this great division of the Mollusca, or soft-bodied animals, are unrepresented in museums or cabinets of shells, either because, like the Octopus, they have no shell, or, like the Squids, Calamaries, and Cuttles, they have only an internal one, which is often very delicate and not easily preserved. But this is not the case with all the Cephalopoda; for the Pearly Nautilus has as solid and compact a shell as any to be found among the whole Molluscan group, and so had the old fossil forms of Nautilus and Ammonite, of Goniatite and Orthoceras, whose chambered shells are to be met with preserved as fossils in rocks of very different ages and countries all over the globe.

* From *kephale*, Gr., a head, and *pous*, Gr., a foot.

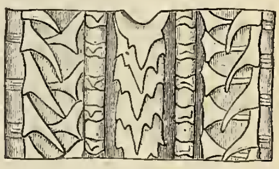
This leads to the consideration of the class characters by which such varied forms of shell-bearing and shell-less animals can be known and recognised when found. Unlike those of some Mollusca, the organs of the Cephalopoda are symmetrically arranged, having their right and left side equally developed. The shells, too, of those forms which possess such an external covering, also grow symmetrically. But only two among all the existing representatives have any external shells, namely, the Nautilus and the Argonaut, all the rest are termed "naked" Cephalopoda, because they have only an internal shell entirely hidden within the soft parts of the animal's body. They have a distinct head, upon which, and around the mouth, are placed the principal appendages of the body in the form of a circle of muscular arms or tentacles. These members fulfil the office alike of seizing and holding the prey, and also act as organs of locomotion; hence the name "head-footed" given to the class. The free-swimmers, such as the Squids, Calamaries, and Cuttle-fishes have fins, which aid them in progression through the water, but all rapid movement is effected by the forcible expulsion of the water through the funnel from the respiratory chamber. Their progress, indeed, is effected stern-foremost, as in the case of a rocket, the backward discharge in both instances being the cause of their onward progress.

The typical forms of the Cuttle-fishes were known and described by Aristotle more than 300 years B.C., but it remained for Professor Owen to point out the existence of two distinct and separate orders of Cephalopods, clearly characterised by their respiratory organs, and to demonstrate how inseparably this organisation was connected with the condition of the two types, the free-swimming Cuttle-fishes on the one hand, and the sluggishly-crawling Nautilus on the other.

Among the great groups of animals already described, various leading modifications of structure were specially noticed, by seizing on which naturalists have been enabled to classify them readily; so also in the Cephalopoda, one group—representing the Squids, Cuttles, Calamaries, the Argonaut, and the Octopus—were found to lead very active lives, and to be excellent swimmers, and as they had only two gills, Professor Owen called them "Dibranchiata." The other group—limited nowadays to the Pearly Nautilus, but formerly, as will be seen anon, quite a dominant class in the seas and oceans of former ages—Professor Owen found to possess four gills, and named them "Tetrabranchiata." They were rather sluggish in their habits, as compared with their modern class-mates, proving clearly that habit and function are directly co-ordinate with one another.

All the Cephalopoda are marine and carnivorous, and possess considerable locomotive power. At the bottom of the sea they can walk about head downwards, by means of the tentacles which surround the mouth, and which are usually provided with numerous suckers or "acetabula."* They are also able to swim, partly by the aid of lateral expansions of the integument or by fins, but chiefly, as has been already stated, by the forcible expulsion of water through the tubular ex-current funnel from the respiratory chamber, in which the two or four plume-like gills are placed.

The mouth is armed with powerful jaws, resembling in form, texture, and position the mandibles of a bird, being especially like a parrot's beak in shape. The tongue is large and fleshy, and, in part, seems to be endowed with the organs both of touch and taste, and, in part, it is armed—as in the Garden Snail, and the Rock Limpet, and other Gasteropods—with recurved spines or teeth.



TONGUE OF THE OCTOPUS.

But the eyes are perhaps the most striking organs in these creatures, being both large and brilliant, and well express the keen activity and alertness for which the majority of this wonderful group are conspicuous.

It has already been noticed that nearly all the existing forms of Cephalopoda belong to the naked-bodied, or internal-shelled, section—the two-gilled (or Dibranchiata). Members of this division cannot rely upon the protective covering of their shells as the Garden Snail does, but like the Garden Slugs, many of which, we shall presently see, have small rudimentry internal shells, they have to rely on cunning, or greater activity, and the substitution of other means of escape and defence, than those which a strong external shell would have afforded. They possess powerful tentacles, furnished with suckers,

* *Acetabulum* (pl. *acetabula*), Lat., a cup, a calyx: a term applied to the suckers or "cups" on the arms of the Cuttle-fish and other Dibranchiate Cephalopods, which have been hence termed *Acetabulifera*.

more perfect organs of vision, and they are able to secrete an inky fluid with which to cloud the water, and so conceal their retreat.

The Dibranchiate order of Cephalopoda also had its representatives in the seas of the ancient world, as the shells called *Belemnites,* or "thunder-bolts," the fossil shells of *Sepia* discovered by Cuvier, and the horny rings of the acetabula or suckers, found by Buckland in the fossil exuviæ of Ichthyosaurus, sufficiently testify; but our knowledge of this order is chiefly founded on observation of existing species. These are extremely numerous; they frequent the seas of every clime, from the ice-bound shores of Boothia Felix to the open main, and floating "gulf-weed," or Sargasso Sea, of the equator Atlantic; they seem, however, to be most abundant in temperate latitudes. Many species frequent the coasts, creeping among the rocks and stones at the bottom; others are pelagic, swimming well, and are found in the open ocean at a great distance from any land.

ORDER I.—DIBRANCHIATA. SECTION A.—OCTOPODA.

FAMILY I.—ARGONAUTIDÆ.

The first section of the Dibranchiate order are called Octopoda, from the fact of their possessing only eight arms furnished with suckers. In it are placed two apparently very dissimilar families, the Argonaut, or Paper Nautilus, and the Octopus, or Devil-fish.

The Argonaut is perhaps the most interesting of this group, from the legends connected with its sailing propensities. It is the only member of the Dibranchiate order which secretes an external shell. But the shell is developed only by the female, the male being destitute of any calcareous covering. It was the *Nautilus* (*primus*) of Aristotle, who described it as floating on the surface of the sea, in fine weather, and holding out its sail-shaped arms to the breeze, a pretty fable, which poets have repeated ever since. Thus the Argonaut, or Paper Nautilus, has been regarded as giving to man the first lesson in the art of navigation. It has been usually represented with six arms extended over the sides of its little vessel to act as oars, and two others upraised as sails. Such having been the universal belief among the earlier naturalists, it is to be expected that poets would not fail to celebrate its nautical powers:—

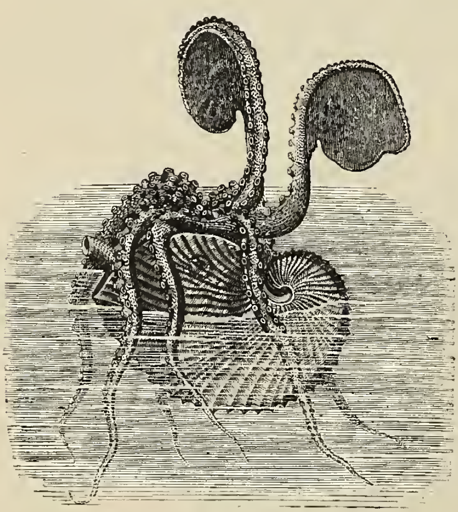
"The tender Nautilus who steers his prow,
The sea-born sailor of his shell canoe,
The ocean Mab, the fairy of the sea,
Seems far less fragile, and, alas! more free.
He, when the lightning-wing'd tornadoes sweep
The surge, is safe—his port is in the deep—
And triumphs o'er the armadas of mankind,
Which shake the world, yet crumble in the wind."—
BYRON.

Again, Pope bids us:—

"Learn of the little Nautilus to sail,
Spread the thin oar, and catch the driving gale."

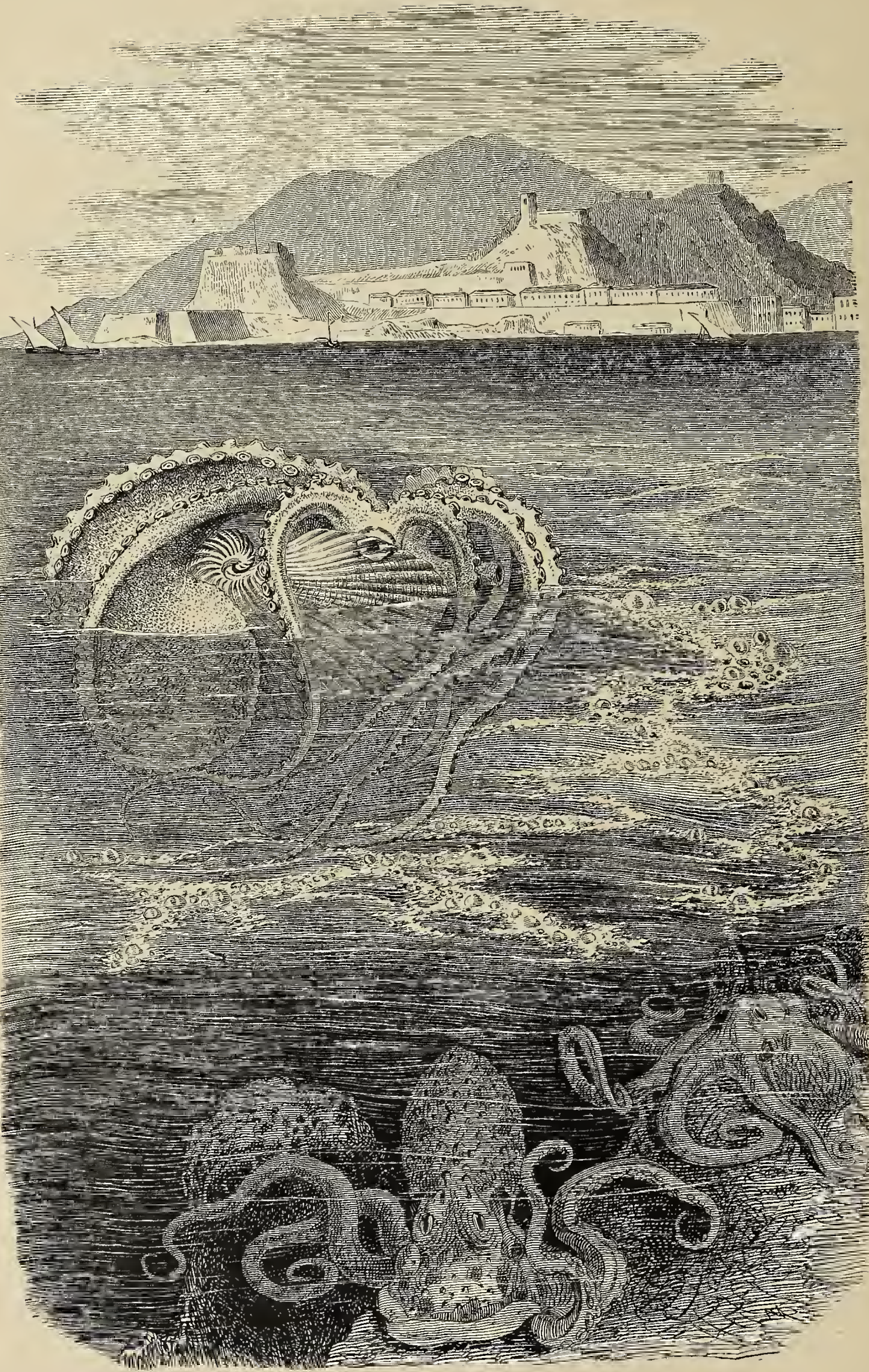
And James Montgomery, in his "Pelican Island," gives a picture so exquisitely finished that even the naturalist can scarcely bring himself to wish that it were different:—

"Light as a flake of foam upon the wind,
Keel upward from the deep emerged a shell,
Shaped like the moon ere half her horn is fill'd;
Fraught with young life, it righted as it rose,
And moved at will along the yielding water.
The native pilot of this little bark
Put out a tier of oars on either side,
Spread to the wafting breeze a twofold sail,
And mounted up and glided down the billow
In happy freedom, pleased to feel the air,
And wander in the luxury of light."



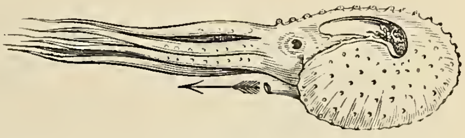
FABLED POSITION OF THE PAPER NAUTILUS.

It is now ascertained that the Nautilus never moves in the manner here described. The account, though so universally accredited, is altogether fabulous. It swims backwards by ejecting water from its funnel, like other Cuttle-fishes. It can creep along the bottom, carrying its shell over its back like a snail,



53 THE PAPER NAUTILUS AND THE OCTOPUS.

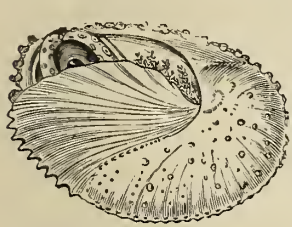
and like many other molluscs, it can rise to the surface; but there the arms are never employed as oars: and those which have the broad expanded membranous disc are never used as sails. Their true function, as ascertained by M. Rang, and confirmed by the experiments of Madame Power, is the secretion of the substance of the shell. They are stretched tensely over its surface, and, when accidental injuries arise, they deposit for its repair the needful quantity of shelly matter. To do this, and to supply what is wanted for the enlargement of the shell with the growth of the animal, is their appointed duty, precisely similar to that of the mantle in Sea Snails and bivalve shells.



ARGONAUT AS IT SWIMS BACKWARD (NATURAL POSITION).

We have spoken of the shell of the Argonaut as an "external shell," but this is true so far only as regards the fact (unique in the molluscan class) that the animal is not actually attached, organically, in any way to its shell. But the shell itself is so completely enveloped and held fast by the expanded lobes of the dorsal shell-secreting arms, that it may, without incorrectness, be called an "internal shell," its delicate, almost paper-like substance, proving its entire unfitness for a protective covering if exposed to the action of the sea.

As before remarked, the female Argonaut alone secretes a shell, which serves as the cradle or receptacle for the attachment of her eggs. The male, which is very much smaller than the female, is naked, and looks like a little Octopus with short, pointed arms. The third arm, on the left side in the male, is specially modified, and is said to be "hectocotylised," being in some instances entirely detached, thus forming, as it were, a distinct organism, with independent locomotory powers of its own. The "hectocotylus" of the Argonaut resembles a little worm, with two rows of suckers along its length, a long filiform appendage at one extremity, and a small swelling at the other. When first discovered it was regarded as a parasite, and termed *Trichocephalus acetabularis* by Delle Chiaje, while the corresponding body, found in an Octopus, was called *Hectocotylus octopodis* by Cuvier. At first it has the form of a sac, within which the slender terminal part of the arm is coiled up. The sac then splits to give exit to the hectocotylus, and its two halves reunite on the outer face of the base of the arm, forming a chamber for the reception of the spermatophores. These are either placed within the mantle-cavity or fixed to the internal surface of the buccal cavity of the female. The hectocotylus is in fact only an arm irregularly metamorphosed and spontaneously detached.



PAPER NAUTILUS IN ITS SHELL.

Four species of Argonaut are known; these all inhabit the open sea, and have been met with throughout the warmer parts of the globe. Captain King records the capture of a Dolphin six hundred leagues from any land, from the stomach of which several Argonauts were taken.

The delicate paper-like shell of one species of Argonaut (the *A. hians*) has actually been met with in a fossil state in the Tertiary deposits of Piedmont. The same species is now found living in the China seas.

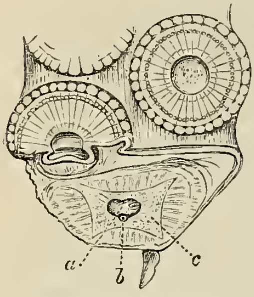
FAMILY II.—OCTOPODIDÆ.

The members of this family have only an internal rudimentary, uncalcified shell, represented by two short styles or plates, enclosed in the substance of the mantle. The arms are alike, but unequal in length, and are united at their base by a broad web. They have two rows of suckers. The body is oval in form and covered with wart-like prominences.

The Common Octopus, found on the British shores (and now so familiar to us by the energetic exertions of Mr. Henry Lee, F.L.S., and the managers of the Brighton Aquarium) is, perhaps, the strangest of all the Cephalopodous class. Its bizarre figure and bright staring eyes, which never close, cannot fail to excite astonishment when seen for the first time, especially when employed in the act of walking on the floor of an aquarium, or in that of swimming by contraction of the membrane

connecting the arms. Like other Cephalopods, however, rapid locomotion is performed stern-foremost by the discharge of water backwards from the funnel.

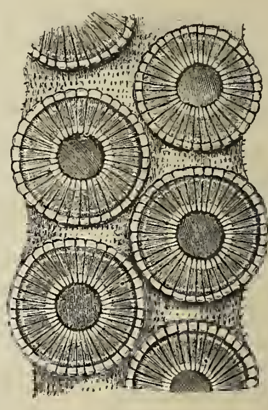
The feet or tentacula appended to the head are by no means exclusively destined to effect locomotion; they are used, if required, as agents in seizing prey, and of so terrible a character are they, that, armed with these formidable organs, the "Poulpe" becomes one of the most destructive inhabitants of the sea; for neither superior strength nor activity, nor even defensive armour, is sufficient to save its victims from the ruthless ferocity of such a foe. A hundred and twenty pairs of suckers, more perfect and efficacious than the cupping-glasses of human contrivance, crowd the lower surface of every one of the eight flexible arms. If the Poulpe but touch its prey, it is enough; once a few of these tenacious suckers get firm hold, the swiftness of the fish is unavailing, as it is soon trammelled on all sides by the firmly holding tentacula, and dragged to the mouth of its destroyer. The shell of the lobster or crab is a vain protection, for the hard and crooked beak of the Cephalopod easily breaks to pieces the frail armour. (Rymer Jones.)



CROSS SECTION OF ARM OF OCTOPUS.
(For explanation of letters see text.)

Professor Owen thus describes the tentacles of the Poulpe, or Octopus:—"Each arm is perforated near the centre of its axis for the lodgment of its nerve (*a*, see woodcut) and artery (*b*): and upon making a transverse section of the arm, these are seen to be lodged in a quadrangular or rhomboidal space (*c*) of a light colour and apparently soft homogeneous texture, but in which a few radiating fibres may be discerned. This part is surrounded by four groups of transverse striæ, forming as many segments of a circle, external to which there are two thin circular strata of fibres. On making a longitudinal section of the part, the striated segments are seen to consist of longitudinal muscular fibres, and of the surrounding strata, the fibres of the internal are longitudinal, and those of the external transverse. It is easy to conceive that, like the tongue in Mammalia, the arms thus organised may be lengthened, shortened, curved, and bent in all conceivable directions.

"The acetabula or suckers with which the internal surface of the arms of the Dibranchiates is provided, vary in relative position, in size, in structure, and in mode of attachment, not only in different species, but in different arms in the same individual, and sometimes in different parts of the same arm. Thus, in *Loligopsis Veranii*, the suckers on the long cylindrical stem are sessile, while those on the expanded extremity are supported on long peduncles; and there is a remarkable instance of suckers having different structure for different functions in the same arm. In the Dibranchiate genera, which are characterised by a soft thin skin, as the Argonaut, Octopus, and Eledone, the suckers are soft and unarmed; in those genera which have a hard thick skin, as the Calamary and *Onychoteuthis*, hooks are developed in the cavities of the suckers.".



SUCKERS OF OCTOPUS.

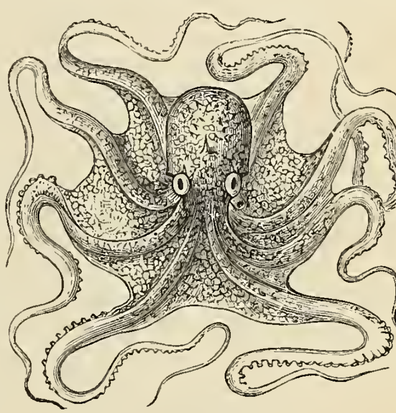
"The circumference of the disc," says Dr. Roget, "is raised by a soft and tumid margin; a series of long slender folds of membrane, covering corresponding fasciculi of muscular fibres, converge from the circumference towards the centre of the sucker, at a short distance from which they leave a circular aperture. This opens into a cavity which widens as it descends, and contains a cone of soft substance rising from the bottom of the cavity, like the piston of a syringe. When the sucker is applied to a surface for the purpose of adhesion, the piston, having previously been raised so as to fill the cavity, is retracted, and a vacuum produced, which may be still further increased by the retraction of the plicated central portion of the disc. So perfect is the mechanism for effecting this mode of adhesion, that in the living Cephalopoda, while the muscular fibres continue contracted, it is easier to tear away the substance of the limb than to release it from its attachments: and even in dead animals the suckers retain a considerable power of adhesion."

The Octopus is crepuscular in its habits, lying concealed in a rock cranny all day, and emerging at dusk in search of prey. Mr. Sylvanus Hanley, the well-known conchologist, who passes every winter

in Italy, states that there are living in the harbour of Leghorn several Octopods having arms at least four feet long, and as thick at their base as a man's wrist. They lie with their bodies squeezed into, and hidden in, crevices in the stonework of the mole and sea-wall, two or three of their arms extended and waving about in the water in readiness to seize passing prey, and the others holding fast to the blocks of stone. Mr. Hanley says that his son, who is a practised shore-hunter, and no coward, having frequent occasion, whilst in search of shells, to climb along a ledge of the rough masonry near the surface of the water, just beneath which was the lurking-place of one of these great creatures, was for some time afraid to pass the spot, in consequence of the animal's formidable appearance; for, as he approached, it would thrust one or two of its disc-studded arms out of water, and stretch them towards him in a threatening manner, in its endeavours to reach him. The Italian divers and bathers have a wholesome dread of these creatures.

The Octopus was the "polypus" of Homer and Aristotle. There can be little doubt that the "Hydra," with its hundred snake-like arms, was an Octopus. On a Greek tomb, at the British Museum, is a bas-relief representation of Hercules attacking the Hydra.

Mr. Darwin, in his narrative of the "Voyage of the *Beagle*," says, that whilst looking for marine animals, with his head about two feet above the rocky shore, he was more than once saluted by a jet of water, accompanied by a slight grating noise. At first he could not think what it was; but he afterwards found that it was an Octopus, which, though concealed in a hole, thus led him to its discovery; and it appeared to him that it could certainly take good aim by directing its tube or syphon on the under side of the body at the intruder.



THE COMMON OCTOPUS.

Although, says Darwin, the Octopus is common at St. Jago in the pools of water left by the retiring tide, they are not easily caught. By means of their long arms and suckers, they can drag their bodies into very narrow crevices, and when thus fixed it requires great force to remove them. At others, they dart tail-first, with the rapidity of an arrow from one side of the pool to the other, at the same instant discolouring the water with a dark chestnut-brown ink. They also escape detection by varying their tints according to the nature of the ground over which they pass.

The following account of a marine diver, attacked by an Octopus, exhibits the behaviour of these animals towards any being that intrudes upon them in their native element:—

On 4th November, 1879, Mr. J. Smale, Government diver, was at work at the bottom of the tideway of the River Moyne, Melbourne. Having placed a charge of dynamite between two large stones, he came up and exploded it, and on descending again found one of the stones thrown out, which he sent up, and then hooked on to another, but could not start it, and having descended again, the current being pretty strong at the time, he stretched himself out on the stone, and reached his right arm down to feel if he could get another small charge under it, not being able to do this in any other position. "My arm," he says, "was scarcely down, however, before I found it was held by something, and the action of the water was stirring up the loose clay, and therefore I could not see distinctly for a few minutes, but when it did clear away I saw, to my horror, the arm of a large Octopus entwined round mine like a boa constrictor, and just then he fixed some of his suckers on the back of my hand, and the pain was intense. I felt as if my hand was being pulled to pieces, and the more I tried to take it away the greater the pain became, and, from past experience, I knew this method would be useless. But what was I to do, lying in this position? I had the greatest difficulty in keeping my feet down, as the air rushed along the interior of my dress and inflated it, and if my feet had got uppermost I should soon have become insensible, held in such a position, and if I had given the signal to be pulled up, the brute would have held on, and the chances would have been that I should have had a broken arm. I had a hammer down by me, but could not reach it to use it on the brute. There was a small iron bar not far from me, and with my feet I dragged this along until I could reach it with

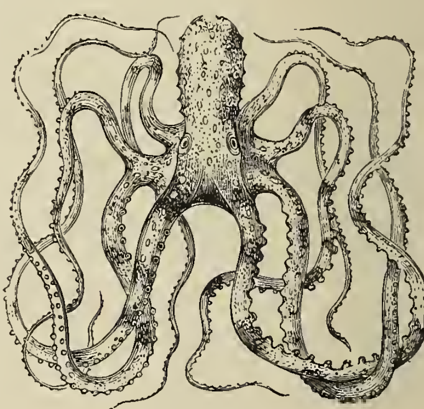
my left hand. And now the fight commenced; the more I struck him, the tighter he squeezed, until my arm got quite benumbed, but after a while I found the grip began to relax a little, but he held on until I had almost cut him to pieces, and then he relaxed his hold from the rock, and I pulled him up. I can assure you I was completely exhausted, having been in that position for over twenty minutes.

OCTOPUS HORRIDUS.

I brought the animal up, or rather a part of it. We laid him out, and he measured over eight feet across, and I feel perfectly convinced that this fellow could have held down five or six men. It is only when a person gets a grip from these brutes that one realises their strength, and it was lucky for me that I was not an amateur, for I can assure you that I had the greatest struggle to get clear of it that I have ever had with any animal under water."*

"The Octopus, like many other predacious animals who seek their prey by night, habitually returns to skulk in the same retreat in the daytime. This practice enabled the resident Octopus of the Brighton Aquarium to enjoy, for many weeks, the run of all the neighbouring tanks by night undetected, for, like the celebrated robber Peace, he was always to be found *at home* in the morning. But the rate at which he thinned the young Lump-fishes in an adjoining tank led to grave suspicion, and after too hearty a meal one evening he imprudently staid out all night, and was 'caught red-handed,' gorged to distention, next morning, in the Lump-fishes' abode.

"On another occasion two Octopuses, kept in the same tank, also took to nocturnal roaming. Leaving their own residence after dark, one went east and the other went west, and, as if by preconcerted plan, neither was content merely to cross the frontier and visit his nearest neighbours, but both passed through, or over, one intervening tank, and settled down amongst the tribes beyond. One of them found himself in a Brobdingnag of crabs—a colony of giants too strong to be successfully invaded even by an armada of Octopods. If he had arrived at Lilliput instead—a tank inhabited by pigmy crustaceans—he would soon have depopulated it, by clutching in his hateful embrace more victims *per diem* than ever an unwelcome foul-mouthed dragon of old demanded as his daily dole of youths and maidens, to satisfy his inconvenient preference for their flesh as his daintiest dish. The other traveller found his way into Lobsterdom, and putting on a bold front, proceeded to attack the chief. The Lobster, though evidently alarmed, 'showed fight,' and the intruder was obliged to retreat, and seek refuge in a cranny of the rockwork. Although the Lobster which bore the brunt of the attack was a very large one, I was at the time surprised that it so decisively vanquished the invader as to save from destruction the other smaller specimens of its kind, which were its companions. For it is an old notion, still generally believed by fishermen, that if an Octopus approaches a 'pot' or 'stalker' in which are Lobsters that have been entrapped, they will cast off their claws, and become literally sick with fright.



OCTOPUS MACROPUS.

"In localities where the Octopus abounds, the crustacea probably learn to regard it as an enemy to be dreaded, but this is certainly not the case with those which I have had opportunities of observing. The common Crabs, on which this animal is habitually fed in the Aquarium, have no knowledge of their danger in its presence. When tossed into the tank, they frequently run towards the monster who is waiting to devour them, and even scramble on to and over his back. It may be that, as in countries previously unvisited by man, the birds and beasts, unacquainted with his destructive powers and carnivorous habits, show no fear of him at first sight, so the Crabs and Lobsters at Brighton so rarely see an Octopus in their native haunts, that they have not learned to recognise their deadly foe."†

* *Illustrated Australian News.* No. 183. Melbourne, Nov. 28, 1879; p. 187.

† Henry Lee; "Aquarium Notes."

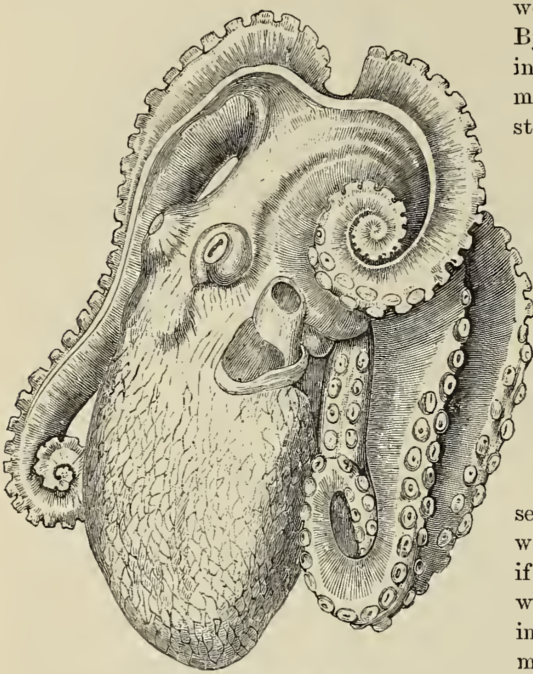
THE COMMON OCTOPUS.

Concerning the spawning of the Octopus, Mr. Lee writes:—"Our Octopus fortunately selected as a suitable site for her nest a recess in the rockwork, close to the front glass of the tank, so that her movements could be easily observed. Her body just filled the entrance to it; and she further strengthened its defences by dragging to the mouth of her cavern two dozen or more of living oysters, and piling them one on another to form a breastwork or barricade, behind which she ensconced herself. Over this rampart she peered with her great sleepless, prominent eyes; her two foremost arms extended beyond it; their extremities coiling and writhing in ceaseless motion, as if prepared to strike out right and left at any intruder. Her companions evidently felt that it was dangerous to approach an excited mother guarding her offspring, and none ventured to go within arm's length of her. Even her forlorn husband was made to keep his distance. If he dared to approach, with intent to whisper soft words of affection into his partner's ear, or to look with paternal pride on the newly-born infants, the lady roused herself with menacing air, and slowly rose till her head overtopped the barrier. By an instantaneous expansion of the pigment vesicles of the skin, a dark flush of anger tinged the whole surface of the body; the two upper arms were uncoiled and stretched out to their utmost length towards the interloper; and the poor snubbed, hen-pecked father, finding his nose put out of joint by the precious baby, which belonged as much to himself as to its fussy mother, invariably shrank from their formidable contact, and sorrowfully and sullenly retreated, to muse, perhaps, on the brief duration of cephalopodal marital happiness.

"The eggs of the Octopus when first laid are small, oval, translucent granules, resembling little grains of rice, and not quite an eighth of an inch long. They grow along and around a common stalk, to which every egg is separately attached, as grapes form part of a bunch. Each of the elongated bunches is affixed by a glutinous secretion to the surface of a rock or stone (never to seaweed, as has been erroneously stated), and hangs pendant by its stalk in a long white cluster, like a magnified catkin of the filbert, or, to use Aristotle's simile, like the fruit of the white alder. The length and number of the bunches vary according to the age and condition of the parent. Those produced by a young Octopus are seldom more than about three inches long, and from twelve to twenty in number; but a full-grown female will deposit from forty to fifty such clusters, each about five inches in length. I have counted the eggs of which these clusters are composed, and find that there are about a thousand in each: so that a large Octopus produces in one laying, usually extending over three days, a progeny of from 40,000 to 50,000. Our brooding French Octopus, when undisturbed, would pass one of her arms beneath the hanging bunches of her eggs, and dilating the membrane on each side of it into a boat-shaped hollow, would gather and receive them in it as in a trough or cradle, exhibiting in its general shape and outline a remarkable similarity to those of the Argonaut, or Paper Nautilus, with the eggs of which Octopod its own are almost identical in form and appearance. Then she would caress and gently rub them, occasionally turning towards them the mouth of her flexible exhalent locomotor tube, like the nozzle of a fireman's hose-pipe, so as to direct upon them a jet of the ex-current water. I believe that the object of this syringing process is to free the eggs from parasitic animalcules, and possibly to prevent the growth of conferva, which I have found rapidly overspread those removed from her attention. Week after week she continued to attend to them with the most watchful and assiduous care, seldom leaving them for an instant, except to take food, which, without a brief abandonment of her position, would be beyond her reach. Aristotle asserts that while the female is incubating she takes no food. This is incorrect. In the tank with our specimen were seven others of her species, and to supply them with food about five-and-twenty living Shore-crabs (*Carcinus mænas*) were daily tossed into it. Although she so seldom left her nest, she generally obtained her share of these, and would seize with her suckers, and draw towards her, sometimes three at a time, one by each of three of her arms. Their shells were soon broken and torn apart by her powerful beak, and when she had devoured the contents the hard *débris* was cast out of her den.

"At the end of the fifth week from the deposit of her ova she began to exhibit considerable irritation and restlessness, in consequence of the annoyance she experienced from visitors trying to rouse her to movement, or to frighten her from her eggs, by knocking at the glass with coins or sticks, and flouting pocket-handkerchiefs in front of her. I found that on some of

these occasions, in her excitement whilst protecting her eggs from the supposed danger, she had torn away the lower portion of some of the clusters, and that their number was considerably diminished. It therefore became necessary to screen her from the public gaze. Fearing also that, notwithstanding the cessation of the interruption to which she had been subjected, she might by her over-fussiness destroy the remainder of her progeny, a portion of her eggs were removed, and transferred to a smaller tank. By the removal of these eggs I hoped also that an interesting question concerning their development might be finally answered. Aristotle had been understood to affirm that the parent Octopus 'incubates' her eggs. I had always expressed very decidedly my opinion, derived from previous experiments on the eggs of the Cuttle-fish and Squid (*Sepia* and *Loligo*), that the ova once impregnated no incubation by the parent is required, or takes place, in a sense, equivalent to that of a fowl developing a chick by the warmth of its body, but that her unremitting attention to them is solely for the purpose of protecting them from injury, keeping them free from animal and vegetable parasites, and preventing their being devoured by fishes.



THE OCTOPUS REPOSING.
(*After a drawing by Mr. T. Davidson, F.R.S.—Frontispiece of Mr. Henry Lee's "The Octopus."*)

"The eggs which were taken away on the forty-second day from their extrusion for special inspection were successfully hatched, and I do not doubt that if they could have been kept free from parasites this would have taken place if they had been detached immediately after they were laid. The young Octopods made their appearance on the 8th, 9th, and 10th of August, the eggs had been extruded on the 19th, 20th, and 21st of June, and thus, although it was proved as I expected, that the development of the embryo does not depend on incubation, the accuracy of Aristotle's statement that its period in the egg is fifty days was completely and satisfactorily confirmed.

"The young Octopus fresh from the egg is of about the size of a large flea, and when irritated is nearly of the same colour. It is very different in appearance from an adult individual of the same species. At first sight it is more like a *Sepia*, without its tentacles, than an Octopus. The arms, which will afterwards be four or five times the length of its body, are so rudimentary as to be even shorter in proportion than the pedal arms of the Cuttle-fish, and appear only as little conical excrescences, having points of hair-like fineness, and arranged in the form of an eight-rayed coronet around the head.

"At this early stage of its existence the young Octopus seeks and enjoys the light which it will, later in life, carefully shun. It manifests no desire to hide itself in crevices and recesses, as the adult does, but swims freely about in the water, often close to the surface, propelling itself backward by a series of little jerks caused by each stroke of the force-pump, which expels a jet of water from the out-flow pipe of the syphon."*

"It is a not uncommon occurrence," says Mr. Henry Lee, "that when an Octopus is caught, it is found to have one or more of its arms shorter than the rest, and showing marks of having been amputated, and of the formation of a new growth from the old cicatrix. Several such specimens have been brought to the Brighton Aquarium, one of which was particularly interesting. Two of its arms had evidently been bitten off about four inches from their base; and out from the end of each healed stump grew a slender little piece of newly-formed arm, about as large as a lady's stiletto, or a small button-hook—in fact, just the equivalent of worthy Capt. Cuttle's iron hook, which did duty for his lost hand.

* "Aquarium Notes on the Octopus," by Henry Lee, F.L.S.

"This reparative power is possessed by some other animals, of which the Star-fishes and Crustacea are the most familiar instances, such as the common 'Five-finger' (*Uraster*), and the Brittle-star (*Ophiocoma*), both of which can throw off their limbs and grow them again; the act is voluntary, and the dismemberment complete. The only joint from which new growth can start in the Crustacea is that connected with the body. The whole limb must be got rid of. The Octopus, on the contrary, is incapable of voluntary dismemberment, but has the faculty of reproducing, as an out-growth from the old stump, any portion of an arm (or leg) which may have been lost by misadventure. I say 'arm or leg,' for one hardly knows which these eight appendages should be called.

"There lingers still among the fishermen of the Mediterranean a very ancient belief that the Octopus, when pushed by hunger, will gnaw and devour portions of its own arm. Aristotle knew of this, and positively contradicted it; but a fallacy once planted is hard to eradicate. The fact is, that the larger predatory fishes regard the Octopus as very acceptable food, and there is no better bait for many of them than a portion of one of its arms. Some of the Cetacea also are very fond of them, and whalers have often reported that when a 'fish,' as they call it, is struck, it disgorges the contents of its stomach, amongst which they have noticed parts of the arms of Cuttle-fishes, which, judging from the size of their limbs, must have been very large indeed. The food of the Sperm Whale consists largely of the gregarious Squids, and the presence in 'spermaceti' of their undigested beaks is accepted as a test of its being genuine. That old fish-reptile, the *Ichthyosaurus*, also preyed upon them; and portions of the horny rings of their suckers were discovered in its coprolites by Dean Buckland.

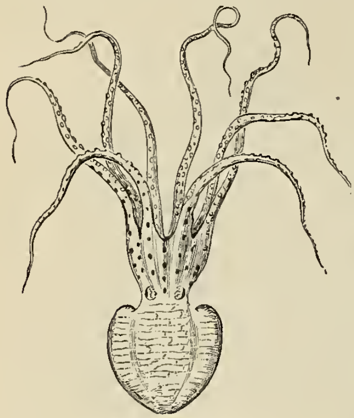
"Amongst the worst enemies of the Octopus in British waters is the Conger. They are both rock-dwellers, and if the voracious fish come upon his cephalopod neighbour unseen, he makes a meal of him, or, failing to drag him from his hold, bites off as much of one or two of his arms as he can conveniently obtain. The Conger, therefore, is generally the author of the injury which the Octopus has been unfairly accused of inflicting on itself. The Curator of the Havre Aquarium describes an attack by Congers on an Octopus which he had thrown into their tank. As soon as the latter touched the bottom it examined every corner of the stone-work. The moment it perceived a Conger it seemed to feel instinctively the danger which menaced it, and endeavoured to conceal its presence by stretching itself along a rock, the colour of which it immediately assumed. Finding this useless, and seeing that it was discovered, it changed its tactics, and shot backwards, in quick retreat, leaving behind it a long black trail of turbid water, formed by the discharge of its ink. Then it fixed itself to a rock, with all its arms surrounding and protecting its body, and presenting on all exposed sides a surface furnished with suckers. In this position it awaited the attack of its enemies. A Conger approached, searched with its snout for a vulnerable place, and having found one, seized with its teeth a mouthful of the living flesh. Then, straightening itself out in the water, it turned round and round with giddy rapidity, until the arm was, with a violent wrench, torn away from the body of the victim. Each bite of the Conger cost the unfortunate creature a limb, and, at length, nothing remained but its dismembered body, which was finally devoured, some Dog-fishes, attracted by the fray, partaking of the feast.

"An Octopus was once placed in the Brighton Aquarium with some 'Nursehounds,' or 'Larger spotted Dog-fishes' (*Scyllium stellare*); for a while, they seemed to dwell together as peaceably as the 'happy family' of animals that used to be exhibited in a travelling cage at the foot of Waterloo Bridge, the Octopus usually remaining within the 'Cottage-by-the-sea' which he had built for himself in the form of a grotto of living oysters, and the Dog-fish apparently taking no notice of him. But one fatal day the 'Devil-fish' was missing, and it was seen that one of the 'companions of his solitude' was inordinately distended. A thrill of horror ran through the corridors. There was suspicion of crime and dire disaster. The corpulent Nursehound was taken into custody, lynched and disembowelled, and his guilt made manifest. For there, within his capacious stomach, unmutilated and entire, lay the poor Octopus who had delighted thousands during the Christmas holidays. It had been swallowed whole, and very recently, but life was extinct."*

* "The Octopus; or, the Devil-fish of Fiction and of Fact," by Henry Lee, F.L.S. For most of the facts and statements here recorded concerning the Octopus, the writer is indebted to his friend Mr. Henry Lee.—H. W.

There are forty-six species of Octopus known to naturalists, and their distribution appears to extend to all the rocky coasts, both in the temperate and tropical regions of the earth.

The *Pinnoctopus*, or finned Octopus, discovered by MM. Quoy and Gaimard on the coast of New Zealand, exceeds three feet in length. Its body is furnished with two lateral fins united behind.


THE PINNOCTOPUS.

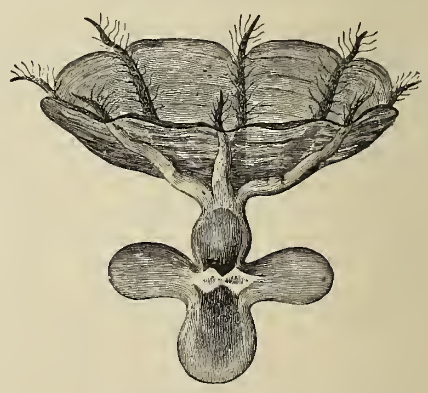
The *Eledone*, like the Octopus, is found on our own coasts and also on the shores of the Mediterranean and as far north as Norway. It has only a single row of suckers on each arm. It is diminutive in size as compared with its cousin the Octopus. One species (*Eledone moschata*) emits a musky smell when irritated or disturbed.

All the species of Octopus possess the faculty shared by certain fishes, and by the Chamæleon, of varying the colour of their bodies to correspond with the hue of the rocky or sandy shore on which they desire to lie concealed. They also change colour remarkably when irritated, becoming as it were "flushed," like an angry school-boy. The *Eledone* makes itself of a peculiarly heightened colour when angry.

In *Cirroteuthis* the body is furnished with two transverse fins, whilst the eight arms or tentacles are joined by a web-like expansion of the body-membrane, so as to form a small inverted parachute or umbrella, for the capture of its prey. This is one of the most northern species of Cephalopods known: the single species *C. Mulleri* inhabiting the coasts of Greenland. It has no shell. Its colour is violet, and it is only ten inches in length.

Philonexis is the smallest of all the Octopods, being from one to three inches in length. It is gregarious in habits, and is one of the few Octopi which have been met with in the open sea, in the Mediterranean, and the Atlantic. Its arms support two rows of suckers. It feeds on small floating mollusca.

Lastly, the *Tremoctopus*, which has its arms partially, or all, webbed half-way up, is remarkable for possessing two large aquiferous pores (or *tremata*) on the back of the head. *Tremoctopus* is a free-swimming Cephalopod, met with in the Atlantic and Mediterranean.


CIRROTEUTHIS MULLERI.

Darwin states that the living Octopods are slightly phosphorescent in the dark. The Octopus, when at rest, curls its dorsal arms over its back, like the Argonaut, shadowing forth, as Forbes believed, the origin and relation of the shell.

About 1780, Denys de Montfort published a work entitled "Historie Naturelle Génerale et Particulier des Mollusques," in which, at Vol. II., p. 256, he gives a representation of a gigantic Octopus throwing its arms over a three-masted vessel. It is stated that he said to his colleague, M. Defrance, "If my entangled ship is accepted, I will, in my next edition, represent it embracing the Straits of Gibraltar, or capsising a whole squadron of ships." (D'Orbigny.)

Although the Cephalopods are seldom eaten in Great Britain, they are appreciated as food by nearly all other maritime nations. Along the western coast of France, and in the countries bordering on the Mediterranean and Adriatic, they form a portion of the habitual sustenence of the people, and are regularly exposed for sale in the markets, both in a fresh and dried condition. Salted Cuttles and Octopus are there eaten during Lent as commonly as salted Cod are brought to table in England on Good Friday; and, thus prepared, generally form a portion of the provisions supplied to the Greek fishing-boats and coasters. "During Advent and Lent, the Octopus is largely consumed by the Orthodox Greek Catholics, amongst whom the use of fish and meat is prohibited in those seasons of abstinence. This strange diet is chiefly obtained from Tunis, and in the Levant and Greek markets its trade name is 'octopodia,' or 'polypi.' In a good season, the Island of Karkenah supplies about

150 tons, of polypi; and the Jerbah waters a third of this quantity. The remaining coast and islands may be calculated to furnish a minimum of 650 cwt. to 700 cwt. of dried Cuttle-fish.

The Octopods prefer the rocky shallows, and are found in those waters, coming from the open sea, to deposit their eggs in the months of January, February, and March; but a considerable number remain permanently near the shore.

In deep water they are taken by means of earthen jars strung together and lowered to the bottom of the sea, where they are allowed to remain for a certain number of hours, and into which the fishes introduce themselves. Frequently from eight to ten Octopods are taken from every jar, at each visit of the fishermen. In less deep water, earthenware drain pipes are placed side by side for distances frequently exceeding half a mile in length, and in these also the Octopods enter, and are subsequently captured. As they are attracted by all white, smooth, and bright substances, the natives deck places in the creek and hollows of the rock with white stones and shells, over which the polypi spread themselves, and so are caught from four up to eight at a time." *

SECTION B.—DECAPODA.

FAMILY III.—TEUTHIDÆ.

Leaving the eight-footed division of two-gilled Cephalopods, we come next in order to the ten-footed family of the *Teuthidæ*,† the name applied by Aristotle to the "Calamaries" and "Squids."

This embraces a very extensive and most interesting series, remarkable not only for the symmetry of their forms, but also as numbering among them some of the largest members of the whole order, the veritable "Anakims and Nephilim," the giants of the Molluscan kingdom.

Besides the eight ordinary feet possessed by the Octopods, these Decapods, or ten-footed forms, are furnished with two greatly-elongated tentacles, having expanded club-shaped extremities covered with suckers. The eight ordinary feet are comparatively shorter than those of the Octopods; the dorsal pair being usually the shortest, and the ventral the longest. The tentacles take their origin within the circle of these eight feet, between the third and fourth pairs; in *Cheiroteuthis* they are six times as long as the animal itself. In *Sepia*, *Sepiola*, and *Rossia* they are completely retractile into large sub-orbicular pouches. In *Loligo* and *Sepioteuthis* they are partially retractile; but in *Cheiroteuthis* they are non-retractile. They serve, like the lasso of the American Indian, to seize their prey, when beyond the reach of the ordinary arms, or to moor the animal to any floating objects, or for safety during the agitation of a stormy sea.

The suckers of the Calamaries differ from those of Octopus, &c., the latter being fixed flat upon the tentacles, whilst the former are supported on peduncles or foot-stalks; they are, moreover, bordered by a horny ring which is finely serrated at the edge. The eyes, which are large, are movable in their sockets, giving them a weird and "uncanny" aspect. In most of this group, the funnel is furnished with an internal valve.

The shell in the "Calamaries" is delicate, translucent, and horny, and called the "pen," or the *gladius* (sword); in the "Cuttle fishes" it is a calcareous "bone" (so-called), or *sepiostaire*. In the genus *Spirula* it is a delicate spiral tube, divided into chambers by a series of nacreous partitions (*septa*). In all, it is internal. Yet, with the exception of *Spirula*, it is not attached to the animal by any muscles, but is only loosely lodged in the middle of the back of the mantle. So loosely does it lie within this cavity, that when the body is cut open it readily falls out. The fossil forms, as we shall presently see, have other modifications of their shells, but all are internal.

Like the gregarious fishes which frequent the open sea, the Squids and Cuttles appear periodically in great shoals on the coasts and banks. This migratory instinct is connected either with the pursuit of particular food, or, as is more frequently the case, it is caused by the females seeking suitable places for spawning. The integument, or skin, of all is provided with *chromatophores*, which are sacs with elastic walls, full of pigment, and provided with radiating muscles, by which they may be drawn out to a size many times greater than that which they occupy in their contracted state. In their dilated condition, the colour proper to the contained pigment becomes plainly visible, while in their contracted state they appear as mere dark specks. It is to the successive expansion and contraction of these

* Report on Tunisian Fisheries, by Mr. W. K. Green, H.B.M. Consul at Tunis.

† *Teuthidæ*—the "Squid" tribe.

chromatophores that the Cephalopoda owe the peculiar play of "shot" colours, which pass like blushes over their surface in the living state. These blushes of colour are especially well displayed by young Cephalopoda just freed from the egg. (Huxley.)

"The Common Squid" (*Loligo vulgaris*) is met with in shoals around the Cornish coast, and is taken by the fishermen at night by torchlight in large numbers for bait. Its body is cylindrical, tapering behind and much elongated in the males; the fins are terminal and united at the base of the body forming a rhomb. The mantle is supported by two ridges in front, and there is a dorsal groove fitting the ridge and grooves on the neck of the funnel. The eyes are large and covered by the skin. The feet are of unequal length, the dorsal ones being the shortest; they are armed with two rows of suckers, furnished with horny dentated margins. The tentacles are partly retractile, with lanceolate club-like extremities bearing four rows of cupping-suckers. These animals are called by the fishermen "pen and ink fish," from the readiness with which they discharge their ink-bag when alarmed or in danger of being captured, and also from the fact of the delicate internal shell (or *gladius*) of the "Calamary" (*Loligo vulgaris*) being in shape extremely like a quill-pen, with an expansion on each side to correspond with the vane of the feather. These delicate pens are multiplied by age, several being found packed closely one behind another in old individuals. (Owen.) The Calamaries are all good swimmers, and gregarious in their habits; they can also crawl head-downwards on their oral disc, or mouth, with the feet expanded. The species of *Loligo*, about nineteen in number, are cosmopolitan in distribution, being found throughout the seas of the globe, living both in the open sea and along our coasts.

The spawn of the Squid (*Loligo vulgaris*) consists of dozens of semi-transparent, gelatinous, slender, cylindrical sheaths, about four or five inches long, each containing many ova embedded in it, and all springing from one common centre, and resembling a mop without a handle. Johann Bodasch, Professor of Natural History at Prague, calculated that one of these mop-like masses contained 39,766 ova; and by counting those embedded in ten of the long, gelatinous, finger-like processes, and weighing them and the remainder, Mr. Henry Lee verified his estimate, and computed that in one specimen there were 42,000 perfect young Squids. It is evident that comparatively few of them live to arrive at maturity, or the sea would teem with them; and in every existing aquarium it has been found impossible to rear the young Cephalopods hatched there. These "sea-mops" are not found attached to anything, and the pelagic habits of the Calamaries render it probable that they are left floating on the surface of the ocean.

"The movements of the 'Little Squid'" (*Loligo media*), says Mr. Henry Lee, "are very graceful and pleasing. They are gregarious, like other Squids, and keep close together. By the action of their tail-fins they can either 'go a-head' or 'turn astern,' and it is very interesting to watch their manœuvres. We once had in one of the tanks four of these 'little Squids' (which were only four inches long), and I was much amused by seeing them perform, in a most ludicrous manner, the quadrille figure called *La Trenise.* Three of them ranged themselves side by side, and advanced towards, and retired from, a solitary one, who, for some reason, was not received into their rank, but faced them. When they withdrew, stern first, to the back of the tank, the lonely one followed them up with a *pas seul.* But there the similitude ended. He was repeatedly driven backwards to his former position, and was not allowed the privilege of taking his partner with him.

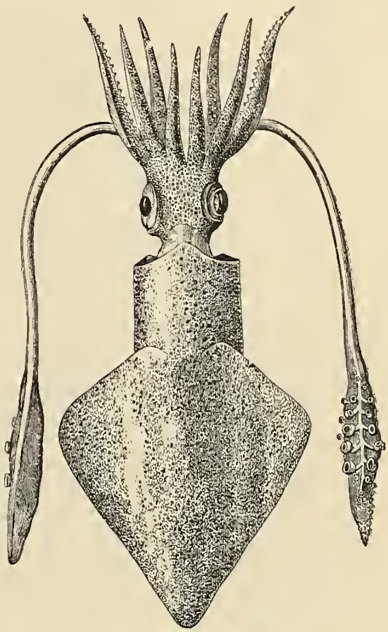
"These little Squids," he adds, "are impudently voracious. I have seen one in single combat with a young Dog-fish about four inches long. At first I thought the fish was the aggressor, and had seized one of the tentacular arms of the little *Loligo* as a good substitute for a worm; but it was soon apparent that the affray had been provoked by the carnivorous Cephalopod, and that the puppy-fish would get the worst of it; so they were separated."

* In the Dibranchiata (Squids, Cuttles, Octopus. &c.), the three principal pairs of nerve-masses, or ganglia, are usually large, and so closely aggregated together, that they are not readily distinguishable. The optic nerves are very large; one or two nerves are given off to the ganglion of the throat and mouth, which are united to form one mass encircling the gullet. The pedal, or foot-ganglion, lies on the posterior side of the gullet, and supplies the large nerves to the arms (feet) or tentacles, and those to the funnel, while the auditory nerves are immediately connected with them. The other nerve-centres (called *parieto-splanchnic*) give off branches to the mantle, the shell-muscles, the branchiæ, the heart, and other internal organs; the inferior buccal ganglion sends nerves along the œsophagus, which end in a ganglion on the stomach. (Hancock, Anatomy of the *Ommastrephes.*)

A species of Calamary found on the coast of Greenland, the *Gonatus amœna*, which, in the form of its pen and of the animal itself, resembles *Loligo* in most respects, has four series of cups on its eight *poda*, or feet, and on its two long tentacular feelers it has numerous small cups, and a single large fixed cup armed with a hook.

The *Sepioteuthis*, of which thirteen species are known, is also closely related to *Loligo*. It has lateral fins as long as the body, and sometimes attains to three feet in length. It is widely distributed geographically from the West Indies to the Cape, the Red Sea, Java, and Australia.

A singular little form, only two inches in length, named *Cranchia* (in honour of Mr. J. Cranch, Naturalist to the Congo Expedition), has been met with in the open sea off the West Coast of Africa. It makes the nearest approach in general character and form to the Octopods, of any of this division of Calamaries. Its pen is long and narrow, its body large and globular, the head is very small, and the eyes are fixed. The feet are short and have two rows of suckers. The tentacular clubs have four rows of cups, and are finned behind. The funnel is furnished with a valve. Only two species are known, of which *Cranchia scabra* is the type.



THE COMMON SQUID.

One of the most diminutive of the Teuthidæ is the *Sepiola Rondeletii* of Gesner, a veritable Lilliputian among Squids, sometimes caught on the south coast of England in Shrimp-nets. The mantle-sac enclosing the body of this little "Tom Thumb" Cephalopod is about an inch in length, and in shape like a short wide-bore mortar. The head may be supposed to be the tompion fixed in the muzzle; and where the trunnions would be are two little flat fins of rounded outline. The large goggle eyes seem to be out of all proportion to the size of their owner; but they are, apparently, "all the better to see with," either to watch for a tender young Shrimp coming within arm's reach, or to perceive an approaching enemy. *Sepiola*, like its comparatively Brobdingnagian relatives, has the faculty of rapidly changing colour, and, if angered or alarmed, its hue is almost instantaneously altered from pale parchment dotted with pink to a deep reddish-brown. In its habits this little animal differs as much from the Sepia as the latter from the Octopus. It naturally buries itself up to its eyes in the sand; but as sand is apt to harbour impurities, which in a bowl or tank become corrupt and generate poisonous sulphuretted hydrogen, the bottom of these receptacles is usually covered with fine shingle. It is most interesting to notice, how, in obeying its burrowing propensities, the *Sepiola* adapts itself to circumstances, and entirely deviates from its customary mode of procedure. To make a sand pit for its hiding-place, it will direct upon it strong jets of water from its funnel, and thus blow out a cavity in which to seat itself, and allow the disturbed particles of sand to settle over and around it; but as the pebbles are too heavy to be thus displaced by its blasting apparatus, it removes them, one at a time, by means of its arms, which are long and strong in proportion to its little short body." (Henry Lee.)

The pen of *Sepiola* is half as long as the back of the animal. Six species of this minute Squid are known from the coasts of Norway, Britain, the Mediterranean, the Mauritius, Japan, and Australia.

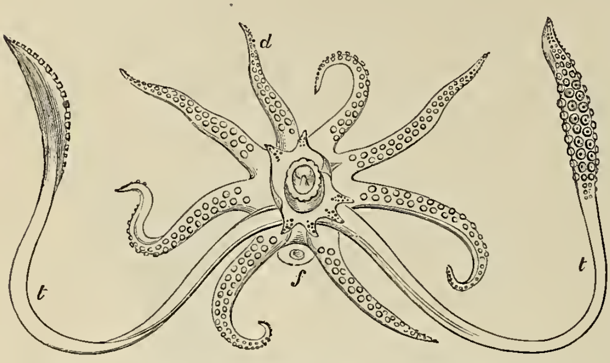
A sub-genus of *Sepiola*, named *Rossia*, by Owen (after Captain Sir James Ross, R.N.), attains a length of from three to five inches, and is represented by six species, one of which is found as far north as Regent Inlet, the others being from Great Britain, the Mediterranean, and Manila.

Another pelagic Squid, named *Loligopsis*,* by Lamarck, has a very elongated tapering body, with short arms, provided with two rows of cups. Its tentacles are very slender; they are often mutilated or wholly wanting. Its caudal fin is rhomboidal, and reminds one of the blade of a screw-propeller. Its pen, which is slender, has a minute conical appendix to its extremity. Eight species of *Loligopsis* are

* From *Loligo*, and *opsis*, Gr., slook.

recorded, all dwellers in the open sea, and therefore good swimmers. They occur in the Atlantic, from the Arctic seas to Madeira ; in the Mediterranean, the seas of India and Japan, and even in the South Sea, and attain a length of from six to twelve inches.

A very interesting member of this family is named *Cheiroteuthis.** Although the length of its body is often less than three inches, its tentacular arms measure three feet in length, and its other arms eight inches to one foot. Its ventral arms are longest. Its long slender tentacles have single cups or suckers scattered at distant intervals along their stalks, and four rows of pedunculated claws on their expanded extremities. The pen, which is slender, is slightly winged at both ends. The fin is broadly rounded, and pointed at its extremity. Two species are described, one of which has been met with in the Mediterranean, the other on the Gulf-weed in mid-Atlantic.



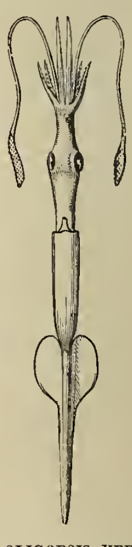
BUCCAL ASPECT OF COMMON SQUID. (*After S. P. Woodward.*)
d, Dorsal Feet or Arms; *f*, Funnel; *t*, *t*, Tentacles.

In *Histioteuthis* †, the terminal fins are rounded; the body is very short, the head being larger almost in proportion. The feet, with the exception of the ventral pair, are webbed high up, thus forming a semi-parachute. The tentacles are long, and placed outside the web formed by the union of the three dorsal pairs of feet; the ends of the tentacles are armed with six rows of cups or suckers with dentated borders. The pen is short and broad-bladed, like an old bronze arrow-head in form. Two forms of this genus inhabit the Mediterranean in the open sea.

The Clawed Calamary (*Onychoteuthis* ‡) has an elongated, cylindrical body, terminating in a broadly-expanded, rhombic, somewhat-pointed caudal fin. The feet are unequal, with two rows of suckers on each. The tentacula are long and powerful, the club-shaped extremity being armed with a double series of hooks, and having usually a small group of suckers at the base. The shell, which is narrow, terminates in a slender, hollow, conical point.

Perfect as is the apparatus of suckers, with which the prehensile organs of the Dibranchiate division of the Cephalopoda are provided, still, it would seem, there are circumstances in which even these would be insufficient to enable their possessor to fulfil all the offices in the economy of nature for which it was designed ; and in those species which have to contend with the agile, slippery, and mucous-clad fishes, more powerful organs of prehension are superadded to the suckers.

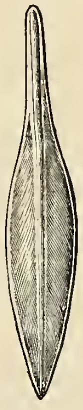
In the Calamary the base of the piston of each sucker is inclosed by a horny hoop, the outer and anterior margin of which is developed into a series of sharp-pointed, curved teeth. These can be firmly pressed into the flesh of a struggling prey by the contraction of the surrounding transverse fibres, and can be withdrawn by the action of the retractor fibres of the piston. Let the reader picture to himself the projecting margin of the horny hoop developed into a long, curved, sharp-pointed claw, and these weapons clustered at the expanded terminations of the tentacles, and arranged in a double alternate series along the whole internal surface of the eight muscular feet, and he will have some idea of the formidable nature of the carnivorous *Onychoteuthis*.


LOLIGOPSIS VERMICULARIS.

We cannot quit this part of our subject without noticing a structure which adds greatly to the prehensile powers of these uncinated Calamaries. At the extremities of the long tentacles, in addition to the clawed suckers, a cluster of small, simple, unarmed suckers may be observed at the base of each of the expanded, club-like extremities. When these small, simple suckers are applied

* *Cheir*, Gr., a hand, and Gr., *teuthis*, a Squid. † *Histion*, Gr., a veil, and *teuthis*.
‡ *Onyx*, Gr., a claw, and *teuthis*.

to one another the tentacles are firmly locked together at that part, and the united strength of both the elongated peduncles can be applied to drag towards the mouth any resisting object which has been grappled by the terminal hooks. There is no mechanical contrivance which surpasses this structure. The obstetric forceps, invented by Sir J. Y. Simpson (in which either blade can be used separately, or, by the interlocking of a temporary joint, be made to act in combination), is stated to have been suggested by these tentacular arms of the Calamary. [Owen.] Specimens have been taken of this form varying in length from four inches to two feet. Six species belonging to this genus have been described, which, like so many of its congeners, have been met with in seas as broad as the Atlantic, the Pacific, and the Indian Ocean. These uncinated, or "Clawed Calamaries," are solitary animals, frequenting the open sea, and especially the banks of floating gulf-weed in the "Sargasso Sea." *O. Banksii* ranges from Norway to the Cape and Indian Ocean; the rest are confined to the warmer seas. *O. Dussumieri* has been taken when swimming in the open sea 200 leagues north of the Mauritius.



THE PEN OF THE CALAMARY.

The Armed Calamary (*Enoploteuthis* *) approaches in size to that of the largest Cephalopods, of which we shall presently speak. It is probably six feet in length (if not larger) when adult; but it seems doubtful whether there is any very exact limit to the growth of some of these larger forms, if they happen to survive their infancy and youth without coming to an untimely end. The pen in *Enoploteuthis* is lance-shaped, but the feet, instead of being furnished with cups or suckers, have each a double series of strongly-curved, horny hooks, concealed by retractile webs. The tentacles are long and feeble, and evidently do not play an important part in the economy of the animal as in the clawed Calamary. Banks and Solander, in Cook's first voyage, found the dead carcass of a gigantic species of this kind floating in the sea between Cape Horn and the Polynesian Islands, in latitude 30° 44′ S., longitude 110° 33′ W. It was surrounded by aquatic birds, which were feeding on its remains. From the parts of this specimen, which are still preserved in the Hunterian Collection, and which have always strongly excited the attention of naturalists, it must have measured at least six feet from the end of the tail to the end of the tentacles. The natives of the Polynesian Islands, who dive for shell-fish, have a well-founded dread and abhorrence of these formidable Cephalopods, and one cannot feel surprised that their fears should have perhaps exaggerated the dimensions and destructive attributes of those creatures.

Ten species have been described belonging to this genus from the Mediterranean and the Pacific. Fossil hooklets arranged in rows, which, doubtless, belonged to a species of *Enoploteuthis*, a great, great ancestor of the one brought home by Sir Joseph Banks, have been met with fossil in the Lias formation of Lyme Regis, in Dorsetshire, and are now preserved in the British Museum of Natural History.

The Sagittated Calamary (*Ommastrephes* †) is a remarkably active member of a restless and cosmopolitan race. The sailors call them "sea-arrows," or "flying Squids," from their habit of leaping out of the water, often to such a height as to fall on the decks of vessels. Colonel Sykes records the fact that in returning from India, while the wind was light and the sea calm, several of these "flying Squids" leapt on board the vessel, falling upon the deck.‡ The body of the Sagittated Calamary is cylindrical, and has a large terminal rhombic fin. The feet have two rows of suckers, and sometimes an internal membranous fringe. The tentacles are short and strong, and armed with four rows of cupping suckers. The pen has a shaft with three diverging ribs and a hollow conical extremity. They vary in length from one to four feet. Fourteen species of these Sagittated Squids have been described from the Atlantic, Mediterranean, Indian, and Pacific Oceans. They are all gregarious in their habits, and frequent the open sea in all climates.

Gould gives the following interesting description of the Sagittated Calamary:—"Their usual mode of swimming is by dilating the water-breathing chamber of their sac-shaped body, and filling it with water. The body is then suddenly contracted, and the water forcibly ejected, so as to propel them backwards with great rapidity. So swift and straight is their progress that they look like arrows

* *Enoplos*, Gr., armed. † *Omma*, Gr., the eye, and *strepho*, Gr., I turn.

‡ *Proceedings of the Zoological Society*, 1833, p. 90, Plate 1.

shooting through the water. Whenever they strike the shore they commence pumping the water with increased violence, while every effort only tends to throw them still farther upon the sands, until they are left high and dry. The body is beautifully spotted with colours, which seem to vary with the emotions of the animal. At one moment they appear to be of a vivid red, at the next a deep blue, violet, brown, or orange. They devour immense numbers of small fish, and it is amusing to watch their movements, and see how, at a distance of several feet, they will poise themselves, and in an instant, with the rapidity of lightning, the prey is seized in their long arms and instantaneously devoured. They, in their turn, are a prey to the larger fishes."

On the coast of Newfoundland the bait used for the Cod-fishery at the commencement of May is the Herring; during June, July, and August the Capelin; and about the end of August and throughout September they use the Squids, which come into the bays in great abundance. They are caught by means of a "jigger," which is a conical piece of lead, round the circumference of the base of which are inserted eight or ten hooks. The fishermen go out in punts Squid-jigging of an evening, to catch bait required for the next day's fishing. About 100 or more Squids are caught by each boat, and thousands of them are taken during the season about 150 or 200 yards from the shore, in tolerably deep water. In many stations more than a dozen boats are engaged in Squid-catching. All parts of the Squid are cut up and used as bait; what is not required the next day is thrown away, or given to the pigs. In the northern district, the fishing spots are between Cape Freels and Cape St. John. The fishing takes place about sun-down. The Squid used so abundantly for bait in the Cod-fishery is *Ommastrephes sagittatus.*

The Squid is of an oblong cylindrical form. The length of the body is from eight inches to a foot, and it is about two inches in diameter. The flesh is said by the fishermen to be remarkably good eating, and to be excellent when fried. About the end of September the Squid disappears.

A crew of three men usually take from 100 to 500 in a day. The Squids come into the bay in such vast shoals that sometimes, during violent gales, hundreds of tons of them are thrown up together in beds on the flat beaches, and their decay spreads an intolerable effluvium around.

The following accounts of the capture of specimens of giant Cephalopods, although necessarily imperfect, and in many instances incapable of careful and complete correlation with one another, suffice to prove that there exist in the North Atlantic numerous living examples of ten-armed Calamaries, of a size surpassing any other members of the Molluscan class.

Some of these may be referred to *Loligo* and *Ommastrephes;* the majority, however, are no doubt properly to be referred to the *Architeuthis monachus* and *A. dux* of Steenstrup, and in this opinion Professor Verrill, who has examined much of the evidence and many of the actual specimens obtained from Newfoundland, agrees. His figures, prepared from photographs and from drawings of parts of several specimens, show it to have had a broadly-expanded internal pen, in form somewhat like that of the ancient genus *Teudopsis,* found fossil in the Jurassic formation. The tail-fin was broadly saggittate, or arrow-shaped, and finely pointed at its extremity. The arms had two rows of stalked suckers, and the tentacles, which were of great length (twenty-four feet), were remarkably slender, and had their expanded extremities armed with four rows of stalked suckers, with horny serrated borders.*

In a letter to the late Dr. S. P. Woodward, Dr. Mörch states that, according to an old Icelandic chronicle, a "sea spectre" (*Ommastrephes*) was driven ashore in 1639, as long and big as a man. It had seven tails, upwards of two yards long (the eighth was very likely lost), and one very long tail (one of the two tentacles, the other being lost), four to five fathoms long. The tails were crowded with buttons, like eyes, with a pupil and eyelid, which were gilt. This evidently refers to the *suckers.*

On the 26th of April, 1875, a very large Calamary was met with on the north-west of Boffin Island, Connemara. The crew of a "curragh" (a boat made like a "coracle," with wooden ribs covered with tarred canvas) observed to seaward a large floating mass surrounded by gulls. They pulled out to it, believing it to be a wreck, but to their astonishment found that it was an enormous Cuttle-fish, lying perfectly still, as if basking on the surface of the water. Paddling up with caution, they lopped off one of its arms. The animal immediately set out to sea, rushing through the water at a tremendous pace. The men gave chase, and, after a hard pull in their frail canvas craft, came

* "American Journal of Science and Arts," 1874, 3rd ser., vol. vii., p. 158; 1875, vol. ix., pp. 123, 177, plates ii.-v.

up with it, five miles out in the open Atlantic, and severed another of its arms and the head. These portions, labelled *Architeuthis dux*, can now be seen in the Dublin Museum. The shorter arms measured each eight feet in length and fifteen inches round the base. The tentacular arms are said to have been thirty feet long.*

In 1861 the French steamer *Alecton* fell in with an enormous Calamary between Madeira and Teneriffe. Vigorous efforts were made to secure this monster, but, after a severe struggle, it succeeded in making its escape, leaving its tail behind. Its length was estimated at about fifteen or eighteen feet, and its eight arms, covered with suckers, appeared to be about five or six feet long.

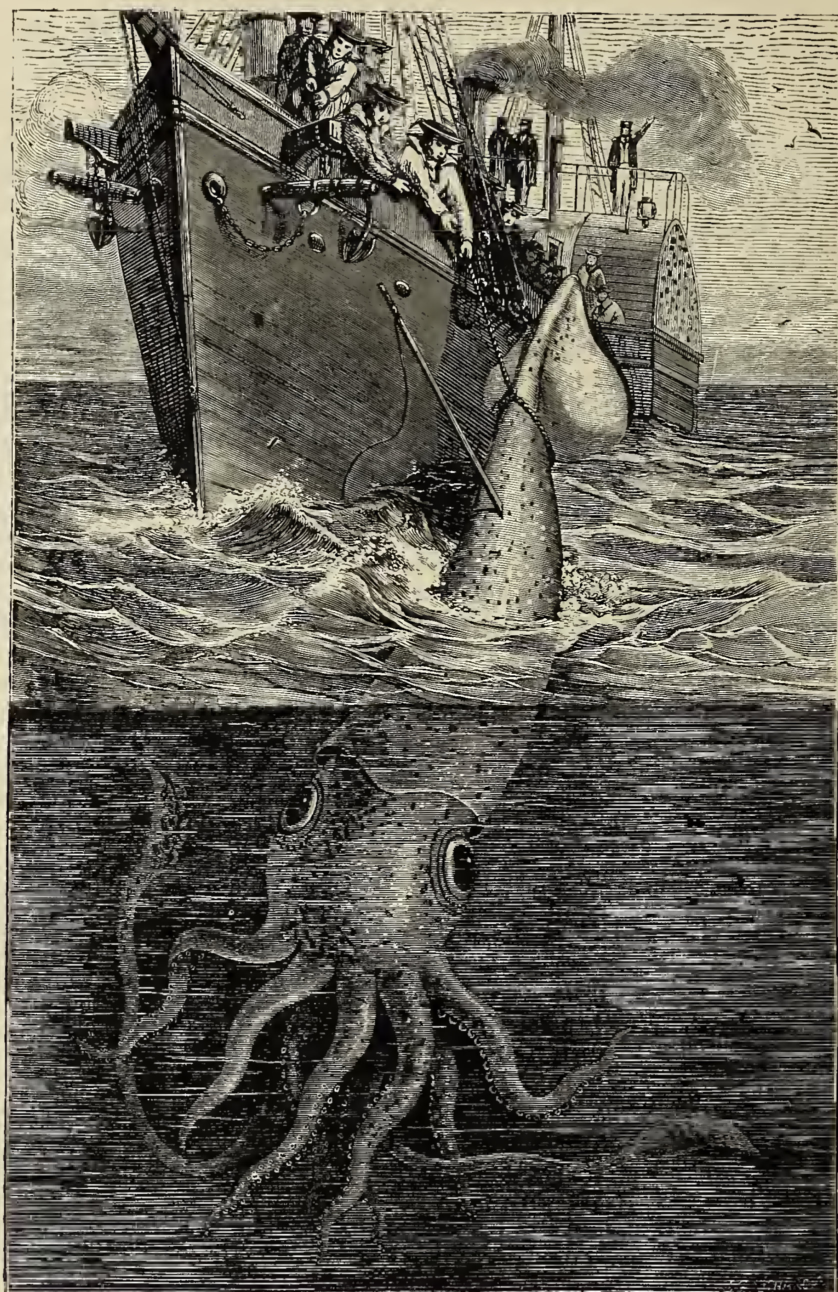
A gigantic Cuttle-fish "was found floating on the surface at the Grand Bank, Newfoundland, in October, 1871, by Captain Campbell, of the schooner *B. D. Hoskins*, of Gloucester, Mass. Dr. A. S. Packard published some account of it in the 'American Naturalist,' 1873, Vol. vii., p. 91. Its jaws were sent to the Smithsonian Institution. Professor Steenstrup, who saw a photograph of them, thought they belonged to *Architeuthis monachus*, an inhabitant of the Northern coast of Europe. The horny jaw, or beak, of this specimen is thick and strong, nearly black; it is acute at the apex, with a decided notch or angle on the inside, about ·75 of an inch from the point, and beyond the notch is a large, prominent, angular lobe. The body of the specimen from which this jaw was taken is stated to have measured fifteen feet in length and four feet eight inches in circumference. The arms were mutilated, but the portions remaining were estimated to be nine or ten feet long and twenty-two inches in circumference, two being shorter than the rest. It was estimated to weigh 2,000 lbs."

"Two fishermen were plying their vocation off Great Belle Island, Conception Bay, October 26, 1873. Suddenly they discovered at a short distance from them a dark shapeless mass floating on the surface of the water. Concluding that it was probably part of the cargo of some wrecked vessel, they approached it, anticipating a valuable prize, and one of them struck the object with his boat-hook. Upon receiving the shock the dark heap became suddenly animated, and, spreading out, discovered a head, with a pair of large, prominent, staring eyes, which seemed to gleam with intense ferocity, the creature at the same time exposing to view and opening its parrot-like beak with an apparently hostile and malignant purpose. The men were petrified with terror, and for a moment so fascinated by the horrible sight as to be powerless to stir. Before they had time to recover their presence of mind the monster, now but a few feet from the boat, suddenly shot out from around its head several long, fleshy arms, grappling with them for the boat, and seeking to envelop it in their folds. Only the two longest of these arms reached the craft, and, owing to their great length, went completely over and beyond it. Seizing his hatchet, with a desperate effort one of the men succeeded in severing these limbs with a single well-delivered blow, and the creature, finding itself worsted, immediately disappeared beneath the waters, leaving in the boat its amputated members as a trophy of the encounter. One of the arms was unfortunately destroyed before its value was known, but the other, when brought to St. John's, and examined by the Rev. M. Harvey, was found to measure no less than nineteen feet; and the fisherman who acted as surgeon declares there must have been at least six feet more of this arm left attached to the monster's body." †

Professor Verrill writes:—"This fragment, which is preserved in the Museum of St. John's, Newfoundland, represents the distal half of one of the long tentacular arms, with its expanded terminal portion covered with suckers, twenty-four of which are larger than the rest; they are in two rows; the border is not serrated. They measure 1·25 inch in diameter; the other suckers are smaller, very numerous; the edge of each is supported by a serrated chitionous ring. The part of the arm preserved measured nineteen feet in length, and 3·5 inches in circumference, but wider, 'like an oar,' and six inches in circumference near the end where the suckers are situated; but its length, when entire, was estimated at forty-two feet." ‡ Professor. A. E. Verrill estimates the entire length of the creature, including its arms, to have been sixty feet. The fishermen told Mr. Harvey that when wounded the Calamary ejected such a vast quantity of ink that the water was discoloured for some 200 square yards around.

* *Zoologist*, June, 1875. † W. S. Kent, *Proceedings of the Zoological Society*, 1874, p. 178.
‡ "Silliman's American Journal," 1875, vol. ix., p. 178.

"A specimen was found alive in shallow water at Coomb's Cove, and captured." Professor A. E. Verrill says of this:—"It is stated that its body measured ten feet in length, and was 'nearly as large round as a hogshead' (ten to twelve feet); its two long tentacless (of which only

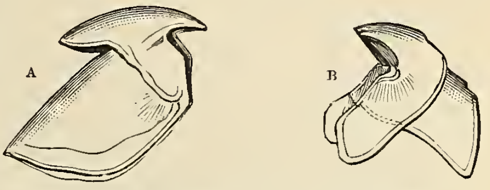


GIGANTIC CUTTLE-FISH HOOKED BY THE FRENCH STEAMER "ALECTON" OFF TENERIFFE.

one remained) were forty-two feet in length, and 'as large as a man's wrist.' Its short arms were six feet in length, by about nine inches in diameter, 'very strong and stout.' The suckers had each a serrated edge. The colour was reddish. The loss of one long arm, and the correspondence of the other in size to the one amputated from the preceding Cuttle-fish, justifies

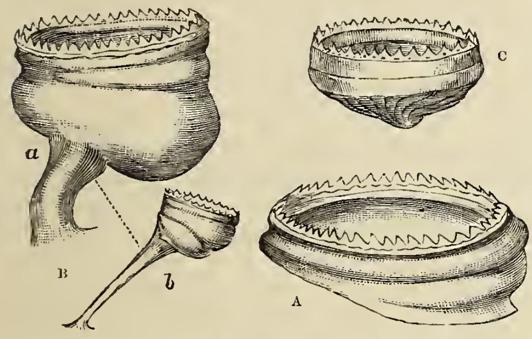
a suspicion that this was actually the same individual that attacked the boat. But if not, it was probably one of the same species, and of about the same size."

A pair of jaws and two suckers were sent to the Smithsonian Institute by Rev. A. Munn. They were taken from a Cuttle cast ashore at Bonavista Bay. He states that it measured thirty-two feet in length and six feet in circumference. Professor Verrill thinks this is probably the entire length, including more or less of the arms. The jaw is large and broad, but thinner than that found by Captain Campbell, and without the deep notch and angular lobe seen in that specimen. It probably belongs to the *Architeuthis dux* of Steenstrup.



UPPER (A) AND LOWER (B) JAW OR MANDIBLE OF ARCHITEUTHIS MONACHUS. (*Steenstrup.*)
(Reduced to one-third nat size.)

On January 31, 1874, the Rev. M. Harvey described parts of a giant Calamary, taken near St. John's, Newfoundland, of which the subjoined is a note :—"A few days ago three of our fishermen residing in Logie Bay, three miles from St. John's, were overhauling a herring-net, when they found entangled in its folds a huge Calamary. With great difficulty they succeeded in despatching it and bringing it on shore, being compelled to cut off its head before they could drag it into their boat. Having purchased it of the fishermen, I have carefully examined and measured it, and have had the head and surrounding arms photographed, as well as the body, both being at present preserved in brine. The body is eight feet in length and five in circumference. The arms, ten in number, radiate from the top of the head. The mouth of the creature consists of a strong horny beak, exactly like that of a parrot in shape, and about the size of a man's fist. The eyes are placed on each side of the head from which the arms extend, and are large, dark, and prominent, the membranous sockets being four inches and a half in diameter. The two longest arms measure each twenty-four feet in length, are only three inches in circumference, and are very tough and strong, and at the extremity are covered with powerful suckers, the largest being one inch and a quarter in diameter, the smallest not larger than a split pea. There are about eighty suckers on each arm, which tapers to a pretty fine point. Each of the eight short arms is six feet in length, and at the point of junction with the head is nine inches in circumference. They taper to a point, and on the under side are entirely covered with a double row of powerful suckers one inch and a quarter in diameter, each having a sharp denticulated edge and a membrane in the centre, which the creature can retract at pleasure, and thus create a vacuum. Each of these short arms has nearly one hundred suckers, and the moment one of them touches its prey it feels the contact, and draws back the membranous piston ; a vacuum is created, and the edges of the disc are pressed against the surface of the victim, with a force equal to the weight of the atmosphere added to the weight of water which is above it. The more the victim writhes it comes in contact with more and more discs in succession, each of which adheres ; and other arms soon encircle it, and bring it within reach of the powerful beak. No fate could be more horrible than to be entwined in the embrace of those eight clammy, corpse-like arms, and to feel their folds creeping and gliding around you, and the eight hundred discs, with their cold adhesive touch, glueing themselves to you with a grasp which nothing could relax, and feeling like so many mouths devouring you at the same time. Slowly the horrible arms, supple as leather, strong as steel, and cold as death, draw their prey under the horrible beak, and press it against the glutinous mass which forms the body. The cold, slimy grasp paralyses the victim with terror, and the powerful mandibles rend and devour.



A, MARGINAL RING OF SUCKER FROM ONE OF THE SESSILE ARMS OF ARCHITEUTHIS MONACHUS (*enlarged two diameters*); B, LARGE (*a*) AND SMALL (*b*) SUCKER FROM THE TENTACULAR ARMS OF SAME (*nat. size*) ; C, LARGER SUCKER FROM TENTACLE OF SAME (*nat. size*).

"No Cuttle of such dimensions as the one I am describing has ever before been captured. If its

arms were extended they would be forty-eight feet between their extremities, while two of the shorter arms would measure thirteen feet from tip to tip. This specimen, although large, is but an infant compared to some which have been seen around these shores. The Rev. Mr. Gabriel assures me that in 1870 two Cuttles were cast ashore at Lamaline, their bodies measuring respectively forty and forty-seven feet. Another gentleman here, whose testimony is thoroughly trustworthy, tells me he measured the body of one which came ashore two years ago, and found it was eighty feet in length. Never until now were Cuttles of such colossal dimensions seen in cold latitudes."*

Four genera of ten-armed Calamaries have been described, founded on the fossil remains of their shells met with in the Liassic and Oolitic formations. They comprise a dilated and spatulate form of fossil pen, named *Teudopsis* by Deslongchamps, of which five fossil species have been described, from the Lias of France and Germany. The genus *Beloteuthis*, of Münster, has a horny lanceolate pen, with a very broad shaft pointed at each end, and with small lateral wings. Of this genus six species have been described, due probably to differences in age and sex. They are found in the Lias of Wurtemberg.

The genus *Geoteuthis* (Münster) has a broad pen, pointed behind; the shaft is wide and truncated in front, the lateral wings are shorter than the shaft. Nine species of this extinct genus of Calamaries have been established on their fossil remains from the Lias of Wurtemberg, Normandy, and Lyme Regis, whilst several undescribed species occur in the Oxford Clay of Chippenham, Wilts.

Besides the pens of this Calamary, the ink-bag, the muscular mantle, and the bases of the arms are preserved in the Oxford Clay. Some of the ink-bags found in the Lias of Lyme Regis are nearly a foot in length, and are invested with a brilliant nacreous layer. They must have belonged to Calamaries of gigantic size. It is difficult to understand how these ink-bags were preserved *full*, as the recent Calamaries "spill their ink" on the slightest alarm. (Buckland.)

"It is an oft-told anecdote that the late Dr. Buckland gave some of this fossil ink to Sir Francis Chantrey, who pronounced it to be of unusually good quality, and with it made a drawing of the specimen from which it was taken. This drawing was afterwards in the possession of the late Frank Buckland. I have also seen a cake of fossil sepia—prepared by Messrs. Newman for Professor Dick, of Cambridge, about the year 1850—which rubs as smoothly and is as rich in colour as that manufactured from the ink of recent Cuttle-fishes." (Henry Lee.)

Another fossil form is the genus *Leptoteuthis* of Von Meyer, from the Lithographic stone of Solenhofen. The pen of this species is very broad, rounded in front, pointed behind, with obscure diverging ribs. The beaks of some fossil forms are known, and also the hooklets of the arms of probably a clawed form of Calamary from the Lias of Dorsetshire. Specimens of many of these may be seen in the British Museum of Natural History. Wagner's genus, *Acanthoteuthis*, from the Lithographic stone of Solenhofen, is founded on the fossil hooks of a Calamary. These show that the animal had ten nearly equal arms, all furnished with a double series of horny claws throughout their entire length.

FAMILY IV.—BELEMNITIDÆ.

As there is no living representative of this family, we are obliged to base our description entirely on its fossil remains. The fossil shells of this singular Cephalopod have long been known. Probably few forms of extinct animal life have received more attention than the Belemnite† and its allies, a group peculiar to the Secondary rocks.

The earliest notices of this fossil date back to 1553, but their chief historians have been Dr. Buckland (1829-36), Owen (1844), Woodward (1851-6), and Huxley (1864).

The part to which the name "Belemnite" is applied consists of the well-known sub-cylindrical calcareous fossil, called by the quarrymen and peasants "Thunderbolts," "St. Peter's Fingers," &c. It is, in fact, only the "guard," or "rostrum," of the internal shell of a species of "Squid," or "Cuttle," the lower end of which is more or less pointed and the upper is hollowed out, with a conical cavity called the *alveolus*.‡ Into this cavity is inserted a series of conical *septa*, or partitions, which, when fossilised by the infiltration of carbonate of lime, leave behind a number of "meniscus-shaped" casts of the chambers which present the appearance of a series of graduated watch-glasses,

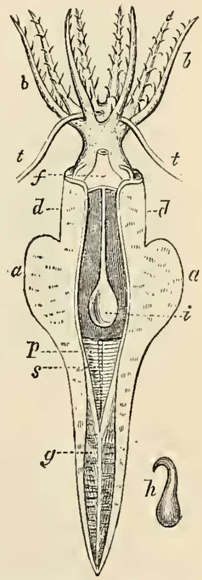
* "Annals and Mag. Nat. Hist.," 4th series, vol. xiii., p. 68.

† From *belemnon*, Gr., a dart.

‡ Lat., *alveolus*, a channel.

piled loosely upon one another. The upper portion of this chambered division of the shell of the Belemnite is enclosed in a thin shell-wall.* The chambers themselves, and septa which divide them, are traversed vertically on one side by a minute pearly tube, called the "siphuncle." The chambered portion is called the "phragmacone."† Rising above the "conotheca," a thin shelly substance is sometimes found. This, which is called by Huxley the "pro-ostracum," is believed to be the homologue of a portion of the pen of the Cuttle-fish.

In addition to this, we now know certainly that the Belemnite possessed an ink-bag, and that its arms were provided with suckers and hooks, and that it had, like its congeners, a horny beak.



BELEMNITE RESTORED.
(*From the "London Geological Journal."*)
b, the Eight Arms furnished with Horny Hooklets; *h*, Hooklet enlarged; *t t*, remains of long tentacular Arms broken off; *f*, position of Excurrent Branchial Orifice; *d d*, Sheath covered by Mantle; *a a*, Fins; *i*, Ink bag; *p*, Phragmacone; *s*, Siphuncle; *g*, Solid-Fibrous Guard or "Belemnite."

Long before Professor Huxley had described (in 1864) a nearly perfect Belemnite from the Lias of Lyme Regis, having all its parts associated together, there had been obtained from the Oxford Clay of Chippenham, by Mr. W. Cunnington, F.G.S., specimens of *Belemnoteuthis*, showing the guard, the phragmacone, the conotheca, the ink-bag, the funnel, the outlines of the fins and *poda*, with the eyes, acetabula, or suckers, and horny hooks. The feet and tentacles in this old fossil genus were of nearly equal length, and furnished with a double alternating series of horny hooks, from twenty to forty pairs on each foot; the fins were large and placed on the centre of each side.

More than one hundred species of Belemnites have been found in a fossil state, ranging from the Lias to the Chalk, and distributed over the whole of Europe. A few species have been found in the Chalk of Southern India, in the Jurassic formation of the Himalayas, and in New Zealand. The guard, which is most commonly the only part preserved, is very variable in its proportions, being sometimes only half an inch longer than the phragmacone, at others one or even two feet in length. The genera belonging to this family are:—Firstly, *Belemnites* (already referred to); secondly, *Belemnitella*, of which six species are described from the Chalk and Greensand formations; thirdly, *Xiphoteuthis*, a curious genus with a single species from the Lias of Lyme Regis; fourthly, *Belemnoteuthis* (of Miller and Pearce, 1842), from the Oxford Clay; fifthly, *Conoteuthis* (of D'Orbigny), from the Greensand of France and England, a form which connects the ordinary Calamaries with the Belemnites.

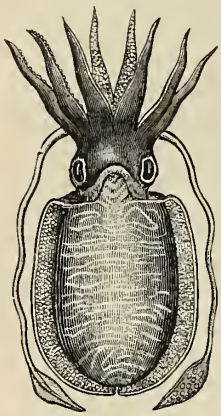
FAMILY V.—SEPIADÆ.

Sepia officinalis, the common Cuttle-fish, is one of the most beautiful and curious of British molluscs; but although its "bone," or shell, is frequently cast up on all our sandy shores, the creature itself is rarely seen and seldom taken. Its body is flattened from back to front, and correspondingly broad laterally. It is rounded below and truncated above, giving to its outline the form of an escutcheon. All around the margin run narrow and delicate fins, one on each side, of equal breadth, except at the extremity, where they meet, and present, as it were, a notched termination to the body. The back is smooth or slightly tuberculated. The head is much narrower than the body, although in itself broad; in the region of the eyes it is very prominent, and crowned above with eight rather short, stout, lanceolate, slightly keeled feet. On their inner sides are four rows of equal and regular, but rather small, suckers, which are globular and stalked, and have simple horny hoops. The margins of the feet are fringed by a membrane, and the fourth pair are crested. The tentacula are very long, borne upon stout smooth peduncles, terminating in clubs, crested on their backs, and bearing on their flat surface, which is expanded at the sides into a plaited flounce, several rows of unequal suckers, of which the central are large and few and the terminal ones numerous and minute. The buccal membrane is attached to the arms by web-like processes.

The colours of this animal resemble the pattern of a Zebra's hide. Centrally, the back is marked by numerous fine, interrupted, irregular bands of white on a dark brown ground; laterally, with

* Called by Huxley the *Conotheca*; from *cones*, Gr., a cone, and *theee*, Gr., a sheath, an envelope, a covering.
† *Phragma*, Gr., a septum, a partition.

broad white stripes, many of which, usually alternate ones, bifurcate at each end, the interspaces being rich vandyke-brown; between them and the lateral fin the skin is tinged with tawny and irregularly spotted. The fins themselves are brownish above, minutely speckled with white; a white line runs parallel with the edge, which is itself bounded by a minutely speckled, very narrow border. The neck is white, with greenish and rosy reflections. The back of the head and arms are rich brown, becoming faint and passing into specks on the sides of the latter. The eyes are black. The tentacular arms are white, with a few pinkish-brown dots. The entire under surface is bluish-white, with rosy specks. No figure that we have seen gives a true idea of the rich painting of the common Cuttle-fish. The female is wider than the male. The "bone," or shell, is thick, but depressed to an ovate-oblong form, varying a little in shape in different examples; it is very regular and symmetrical, smooth and corneous at the sides, and more or less furrowed and rugose over the greater part of its surface. Near the posterior extremity is seen the hard mucro. It is most prominent in young specimens. The under surface is convex, depressed and hollowed out at the sides behind. The margin projects widely below, and curves upwards and inwards, and expands in a wing-like form below around the nucleus of the shell. The substance of the "cuttle-bone" is composed of numerous shelly laminæ, separated from each other by a perpendicularly fibrous calcified tissue, exhibiting a shiny white and satiny lustre, and having a pumiceous aspect and feel. Thus extreme lightness, in proportion to its bulk, is given to this body.


THE COMMON CUTTLE.

The bone equals the body in length, without the fins. A full-grown Cuttle-fish measures ten inches in length. The breadth of the body is six inches. The arms are five inches in length, and the tentacles a foot and a half long.

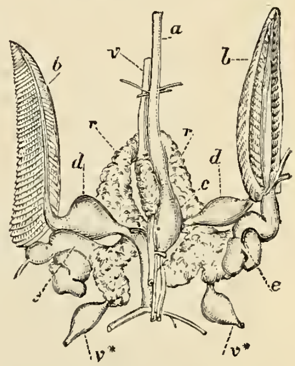
This animal seems to be generally distributed around the shores of Britain. It is scarce to the north of our island, more common to the south, and exceedingly abundant in the Mediterranean. The eggs are dark, oval-shaped, with prominent summits, and have a membranous ring at their bases, by which they are attached to sea-weed, or fixed to each other so as to form masses of considerable numbers.*

Although, as already seen, we are no longer studying animals belonging to the vertebrate classes, but to the invertebrata, nevertheless we find, besides the internal shell of the Cephalopoda, that the principal nerve-mass, or "supra-œsophageal ganglion" (so called because it is placed *above* and around the gullet, or œsophagus), is protected by a thick cartilage, which extends in different directions, so as to afford a basis of attachment to the chief muscles of the body, thus serving in lieu of an internal skeleton. It is most largely developed in the Dibranchiate division, and especially so in the Cuttle-fish. In the Cuttle the cranial cartilage completely surrounds the gullet, and expands above into a cavity to protect the brain, is hollowed below into cavities to form organs of hearing, and at the sides to give support to the back part of the orbits. The long lateral fins are each supported by a narrow flattened plate of cartilage, to which the powerful fin-muscles are attached by fibro-cartilaginous laminæ, resembling those which support the fins of the cartilaginous fishes, such as the Ray. (Owen.) There is a strong muscular heart in all the animals belonging to this class, which, when single, is always systemic. Besides the aortic or systemic heart, which has only one cavity or ventricle, each vessel leading to the gills has a dilated contractile portion, which dilatations may be considered as branchial hearts, so that there are three separate contractile portions of the circulatory system.

"The common Cuttle-fish, often called by sailors the 'Scuttle,' when seen alive, is a lovely object. Unlike the skulking, hiding Octopus, but equally rapacious, it loves the daylight and the freedom of the open sea. Its predatory acts are not those of a concealed and ambushed brigand lying in wait behind a rock, or peeping furtively from within the gloomy shadow of a cave, but it may better be compared to the warlike Comanche vedette, seated motionless on his horse, and scanning from some elevated knoll a wide expanse of prairie, in readiness to swoop upon a weak

* Forbes and Hanley: "British Mollusca."

or unarmed foe. Poised near the surface of the water, like a hawk in the air, the Sepia moves gently to and fro in its tank by graceful undulations of its lateral fins, an exquisite play of colour occasionally taking place over its beautifully barred and mottled back. When thus tranquil, its eight pedal arms are usually brought close together, and droop in front of its head, like the trunk of an elephant shortened, its two longer tentacular arms being coiled up within the others and unseen. Only when some small fish is given to it as food is its facility of rapid motion displayed. Then, quickly as a Kingfisher darts upon a Minnow, it pounces on its prey, enfolds it in its fatal embrace, and retires to a recess of its abode to tear it piecemeal with its horny beak, and rend it into minutest shreds with its jagged tongue. In shallow water, however, it will often rest for hours on the bottom, after a hearty meal, looking much like a sleepy Tortoise. The Cuttle-fishes are so voracious that fishermen regard them as unwelcome visitors. Some localities on our own coast are occasionally so infested by them that the drift netting has to be abandoned, in consequence of their devouring the fish, or rendering them unsalable by tearing them with their beaks as they hang in the meshes.



BRANCHIÆ AND HEARTS OF COMMON CUTTLE.

a, Aorta; *v*, Vena cava; *v*v**, Vesical veins; *c*, Systemic heart; *d d*, Dilatations of Branchial veins; *e e*, Branchial hearts; *b b*, Branchiæ; *r r*, Renal organs.

"The *Sepia* seldom lives long in confinement. Although, like the Calamaries, it often swims gently forward by the use of its fins, its usual mode of rapid progress is the same as that of the Octopus, namely, darting backwards by the ejection of a stream of water through the funnel. In a limited space like an aquarium tank there is not sufficient room for its rocket-like rush, and therefore its hinder extremity so frequently comes in contact with the rockwork that the skin is worn through until the edge of the internal shell, or 'sepiostaire,' is visible, and death follows. The animal cannot see behind it, and so it often happens that it similarly comes to grief in its natural habitat, especially in calm weather, when, as Professor Edward Forbes says, 'not a ripple breaks upon the pebbles to warn it that the shore is near. An enemy appears; the creature ejects its ink, like a sharpshooter discharging his rifle ere he retreats, and then, darting away tail foremost, under cover of the cloud, grounds itself high upon the beach, and perishes there.'" *

It is somewhat remarkable that whilst the Octopus shuns the light, and retreats from that of the lanthorn, the Cuttle and Squid are attracted by it. At Trincomalee, at certain seasons of the year, the bay is illuminated during the night by hundreds of lights of fishing-boats moving hither and thither. A dead Cuttle is generally the bait used. This is suspended in the water, and when hauled in from time to time one or more of its species are found fast to it, and feeding on their deceased relative. When removed from the water they emit a peculiar "squelching" noise, which has been compared to the grunting of a hog. It is caused by the forcing of air instead of water through the siphon tube.

"John Hotton (a fisherman of Polperro) says, that some time since he was at sea for the purpose of catching Cuttles, when the night was so dark that, though Cuttles were in plenty, and followed the bait to the surface, he could not see to hook them. He then desired his son to take a lanthorn, and hold it close to the water, so that he might see, when, to his surprise, a great many Cuttles gathered round the light, and without bait or hook he caught eighteen by hooking them with the rod (gaff). Since then he has more than once put the same plan in practice."†

The crystalline lens of the eye, which is soft in quadrupeds and cartilaginous in fishes, is very solid in the Cephalopoda. It is almost calcareous, and very peculiar in form. It consists of two double concave portions, divided by a deep groove, in which are inserted the ciliary processes. The two halves, which are almost globose at their outer surfaces, separate easily, and exhibit internally a series of concentric coats, which reflect with a beautiful nacreous opalescence and play of colours. In some parts of Italy, as in Genoa, the women on festival days use these lenses as beads for necklaces. They were also used as ornaments by the ancient Peruvians, and several of a large size, which were found in the tombs, and in the eyes of mummies from Peru, are preserved in the Christy

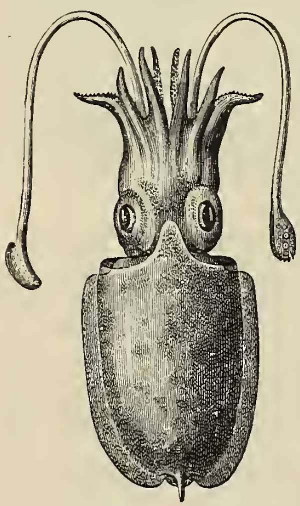
* Henry Lee: "Aquarium Notes."

† From Jonathan Crouch's MS. "Diary," dated 1819.

collection, British Museum. Mr. Stutchbury mentions that the Sandwich Islanders sold these lustrous eyes to the Russians as pearls.

A remarkable organ with which some of the Cephalopoda are provided is a sac, popularly called the "ink-bag," in which is stored a deep black secretion, which they are able to employ at will as a protection from rapacious enemies. On the approach of a suspected foe the animal discharges a quantity of this dense fluid, which renders turbid the surrounding water, and thus enables its owner to escape in the obscurity. There is a communication between this ink-bag and the funnel or locomotor-tube, so characteristic of all the Cephalopoda, so that when the ink is ejected it is forcibly emitted with the stream of water, which produces the rocket-like backward motion. The very effort to escape thus serves the double purpose of propelling the creature away from the danger and discolouring the water through which it moves.

"The position of the ink-bag varies in different families. In the Octopus it is buried in the substance of the liver, and this animal does not emit its ink so readily as the Cuttle or the Squid. They very rarely do so in captivity, except when greatly exhausted or persistently irritated. It has been said that after being a few hours in captivity the Octopus loses the power of secreting ink. There is no foundation at all for such a statement. When placed in a tank especially reserved for it, in which are no enemies to cause it fear, it has no need to conceal itself, and therefore does not unnecessarily eject its cloudy fluid." Mr. Lee states, "I have never dissected an Octopus, no matter how long it might have lived in confinement, without finding the ink-bag fairly charged, though some of its contents are sometimes emitted when the animal is at the point of death."


SEPIA ELEGANS.

"The Cuttle (*Sepia*) discharges its ink on the slightest provocation; and this is sometimes very troublesome and annoying when this species is exhibited in an aquarium. The quantity of water its ink will obscure is really surprising. The fluid is secreted with amazing rapidity, and the black ejection frequently occurs several times in succession. I have (says Mr. Lee) often seen a Cuttle completely spoil in a few seconds all the water in a tank containing 1,000 gallons."

When first taken, the Sepia is most sensitively timid. Its keen, unwinking eye watches for and perceives the slightest movement of its captor, and if even most cautiously looked at from above, its ink is belched forth in eddying volumes, rolling over and over like the smoke which follows the discharge of a great gun from a ship's port, and mixes with marvellous rapidity with the water, whilst the animal simultaneously recedes to the best shelter it can find.

It is worthy of notice that the Pearly Nautilus and the allied fossil forms are without this means of concealment, which their strong external shell renders unnecessary for their protection.

"Fishermen are well acquainted with the fact that the Cephalopods—at any rate, our British representatives of the *Sepiidæ*, *Calamaries*, and *Octopoda*—habitually discharge, when taken, a jet of black water, and the two former sometimes eject their ink in the faces of their captors. It has been regarded as doubtful whether this is an intentional act or whether it is accidental, and consequent on the bringing of the orifice of the siphon-tube above the surface, and the removal of the resistance to the outpouring current which, when ejected under water, would in the one case have been a means of locomotion, and in the other of concealment of their whereabouts. Some have supposed that the emission is involuntary, and is produced much in the same way as the water is tossed up in spray by the screw of a steam-vessel when her stern rises whilst she is pitching heavily in a rough sea. Others who have experienced the effect of this habit of the animal's have persistently asserted that they take deliberate aim, with the motive of aggression or self-defence.

"The 'ink' which the Cuttle-fish has the power of ejecting when alarmed for the purpose of obscuring the water and hiding its own retreat was formerly used in writing. Cicero mentions this use of it, and from it also is made the true 'sepia' of artists. I have more than once lately seen it stated that the ink of the Cuttle-fish is no longer employed for this purpose, and that 'sepia' is now

prepared from lamp-black. A great deal of rubbish of this kind is probably sold; but I have recently seen at Messrs. Newman's, the well-known artists' colourmen, in Soho Square, thousands of ink-bags of Cuttles in the raw state ready to be manufactured into 'sepia.' The fishermen of some of our southern counties, when cleaning Cuttles and Squids for bait, habitually dry the ink-bags and their contents, and preserve them till Messrs. Newman's agent visits the district and collects them. If the Newfoundland fishermen, when 'Squid-jigging,' would take the trouble to preserve the ink-bags, they would find a ready sale for them, and might make of them a profitable perquisite. The beautiful drawings with which Cuvier illustrated his 'Anatomy of the Mollusca' were executed with the ink which he had collected whilst dissecting many specimens of Cephalopoda; and it is well known that fossil Cuttle-fishes have been found with the ink-bag perfect, and that from its contents excellent 'sepia' has been obtained." (Henry Lee.)

"The eggs of the various families of Cephalopods differ greatly from each other. Those of the Cuttle (*Sepia*) are like black grapes, each having a flexible stalk, looking and feeling like india-rubber. The mother takes a turn with this stalk round the stem of the twig or seaweed to which she wishes to attach the egg; the india-rubber-like material is soft and sticky when first laid, and so, instead of splicing the loop, she brings the end round to the base of the stalk, close to the egg, and cements or welds it there into a solid ring. Thus the eggs are attached one by one. Sometimes the stalk of one is fastened round that of another, and occasionally the process is repeated until the whole mass is made up in this way, without any central stem. The work is as well and neatly done as if skilled hands had been employed on it, but how the mother Cuttle-fish effects it I believe no one knows. I hope we may some day have opportunities of watching her.

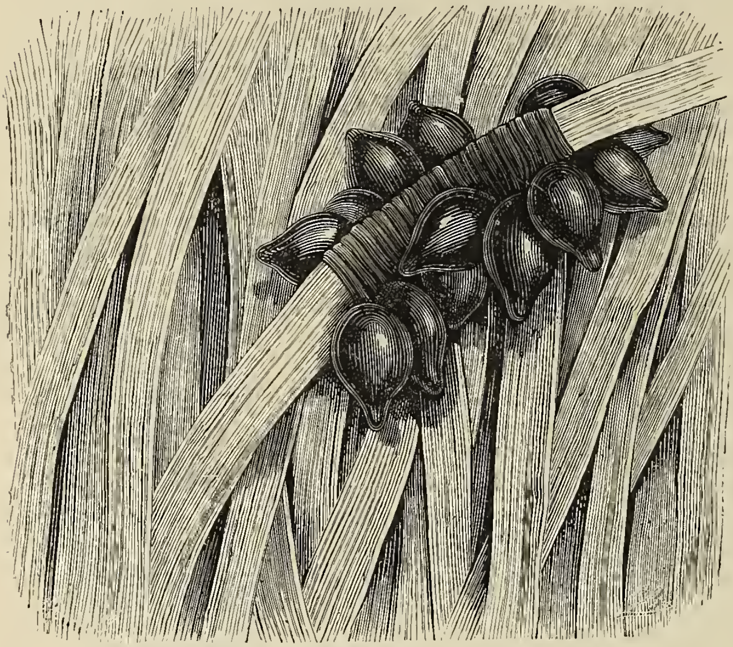
"Aristotle wrote that the Sepia fastens her eggs near land upon seaweeds, reeds, and other bodies which may be found on the shore, and even around sticks and faggots placed there for the purpose of entrapping her. 'She does not lay them all at once,' he says, 'but at several intervals, the operation lasting fifteen days; and after the oviposit is completed she sheds her ink upon them, which turns them from white to black, and causes them to increase in bulk.' He also avers that she hatches them in the place where she has deposited them, and is often to be seen with her body resting on the ground and covering them. I do not think that the dark hue of the membranous integuments of the eggs, and of their pedicle, or foot-stalk, is in any way attributable to their being stained by the animal's inky secretion, although I have frequently seen masses of these eggs, the integuments of which were not black, but perfectly colourless and pellucid. That the mother broods over them, and protects them till they are hatched, is quite in accordance with the observed habits of the Octopus, and is therefore not improbable. But, as with the Octopus, I am satisfied that no incubation takes place.

"At intervals, for many years past, I have found the eggs of the Sepia and Loligo in early stages of their development, and have hatched them out, without any assistance from their parent, by merely suspending them in sea-water in a tank or tub, and changing the water frequently. The same also has been frequently done in the Brighton Aquarium. This having been proved and demonstrated by actual experiment, it is unnecessary to fortify facts by reasoning. But I have seen a branch of a tree or shrub, measuring more than two feet in height from the base of the broken stem to the upper part of its branches, and fourteen inches from side to side across the tips of the twigs, covered with the eggs of Sepia in single rows along them. I cannot, of course, be certain that these were all laid by one female, but it is evident that one could not cover so great an area continuously as an incubator, and that, if it were possible, she would subject herself to unnecessary toil in so doing, seeing that they were all hatched in a tank, after having been for about ten days deprived of maternal care.

"The young Sepia, when born, is much larger than a baby Octopus or Squid. It is of about the size of a rather small horse-bean. When about half developed, the little animal has the head and eyes disproportionately large, but gradually acquires a greater resemblance to its parent. If the black integument be removed, as one would skin a grape, it may be seen moving in the fluid which fills the egg. Cut down to the little living grape-stone under water, and away it will swim, with all its wits about it, and in possession of all its faculties, with as much facility and self-possession as if it had considerable knowledge of the world. It sees and avoids every obstacle, and if you take it out of the water in your hand, the precocious little creature, not a minute old, and not sufficiently matured to leave the egg naturally, will spurt its ink all over your fingers. You may tame an old Cuttle-fish,

and it will learn to know you are a friend; but the youngsters are as shy as human babies, and regard every one but their mother as an enemy."*

The preference for the light, described by Mr. Henry Lee, as exhibited by the young Octopus, appears to be common also to the young Squid and Cuttle-fish. The latter generally seek the surface of the water; sometimes swimming gently by means of the locomotor-tube and the undulating movement of the marginal fins, and at others poising their bodies motionless, as if basking. The habit in these two families is not so surprising as it is in the Octopus, because the adult Sepia and Loligo are not cave-dwellers, but frequent the open sea, and often approach the surface.



EGGS OF THE COMMON CUTTLE-FISH.

The internal shell (*sepiostaire*), incorrectly called the "cuttle-bone" of the Sepia (sometimes also called "sea-biscuit," from its shape, and its being frequently found floating on the surface of the water), is used, when pounded, as polishing powder by jewellers, and, under the name of "pounce," to smooth writing-paper where an erasure has been made with a penknife. Known as "white coral powder," it used to be regarded as the very best dentifrice, and was formerly prescribed in medicine as an antacid and absorbent.

The Roman ladies employed it, burned and pulverised, as a cosmetic for the face; and it was, no doubt, a good substitute for the "pearl powder" now in fashion. Broken pieces of it are also occasionally placed between the wires of the cages of song-birds for them to peck at, instead of chalk or other calcareous substances.

Ten species of Sepia have been established on the fossil remains of "Cuttle-bones" from the Solenhofen limestone. Some of these sepiostaire, or "bones," attained a length of two feet.

Several species have also been founded on the *mucro* (or sharp point or extremity) of fossil shells of Sepia, found in the Eocene Tertiary formation of the London and Paris basins. One species (*Sepia ungula*) occurs fossil in Texas.

INTERNAL SHELL OF THE SEPIA.

Referring to the use of these animals by the Greeks as an article of food, Professor Edward Forbes writes:—"The traveller who, when treading the shores of the coasts and islands of the Ægean, observes—as he can scarcely fail to do—the innumerable remains of the hard parts of Cuttle-fishes piled literally in heaps along the sands, or, when watching the Greek fishermen draw their nets, marks the number of these creatures mixed up with the abundance of true fishes taken and equally prized as articles of food by the captors, can at once understand why the naturalists of ancient Greece should have treated so fully of the history of the Cephalopoda, and its poets have made allusions to them as familiar objects. One of the most striking spectacles at night on the coasts of the Ægean is to see the numerous torches glancing along the shores, and reflected by the still and clear sea, borne by poor fishermen paddling as silently as possible over the rocky shallows

* Henry Lee: "Aquarium Notes."

in search of the Cuttle-fish, which, when seen lying beneath the waters in wait for its prey, they dexterously spear, ere the creature has time to dart with the rapidity of an arrow from the weapon about to transfix his soft but firm body. As in ancient times, these molluscs constitute now a valuable part of the food of the poor, by whom they are chiefly used. We can ourselves bear testimony to their excellence. When well beaten, to render the flesh tender, before being dressed, and then cut up into morsels and served in a savoury brown stew, they make a dish by no means to be despised, excellent both in substance and flavour. A modern Lycian dinner, in which stewed Cuttle-fish formed the first, and roast Porcupine the second course, would scarcely fail to be relished by an unprejudiced epicure in search of novelty."

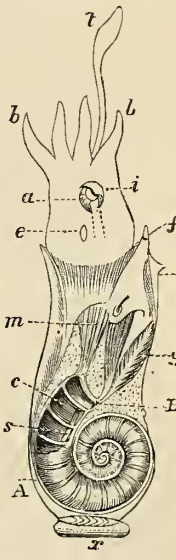
The bone of the Chinese species attains a length of nearly two feet. The Japanese are large consumers of Cuttle-fish as an article of food.

Upwards of thirty species of Cuttle-fishes have been described. Their distribution is world-wide. Two are recorded as British: the *Sepia officinalis* and the more rare *S. biserialis,* of which only the sepiostaire, or internal shell, has been obtained.

FAMILY VI.—SPIRULIDÆ.

Since the publication of "The Zoology of the Voyage of H.M.S. *Samarang,*" in 1848, we have until recently learnt but little concerning the owner and constructor of the beautiful pearly-white shell known as Spirula, whose many-chambered spiral tests (composed of separate whorls, like a little post-horn) are scattered in thousands on the shores of New Zealand, and a few of which are yearly wafted by the warm current of the Gulf Stream to our shores, and have been picked up on the coast of Kerry, in Ireland, at Tenby, in South Wales, and on the coast of Cornwall.

The materials which Professor Owen had at his disposal when he prepared his first account, in 1848, consisted of a headless specimen, brought home by Admiral Sir Edward Belcher, with the hinder part of the mantle torn off; part of another specimen of Spirula, showing the mantle, with the shell attached, taken off Timor; and a very unique specimen of *Spirula Australis,* in Mr. Cuming's collection, "perfect in all its parts except the termination of one of its tentacles," found in a fresh state by Mr. Percy Earl on the shore of Port Nicholson, New Zealand. This last specimen Professor Owen was permitted to draw, but was not then allowed to dissect, and it was not until 1878, after an interval of thirty years, that he was enabled to complete his anatomy of this Cumingian rarity.*



SECTION OF SPIRULA AUSTRALIS.†
(*After Owen.*)

This singular little Squid differs in several important points from the other two-gilled and ten-armed division to which it belongs: in the absence of any well-developed fins; also the two lobes of the mantle seem to embrace the shell, all save one tiny portion, which may at times have been slightly exposed by the contraction of the mantle-lobes, though this seems improbable.

The base of the body, which in the Squids ends in a pointed, often arrow-shaped, fin, in Spirula terminates in an elliptical convex substance with a central depression (x), in the midst of which is a pore terminating blindly. "If," says Professor Owen, "the disc were applied to a flat surface and the central part were withdrawn from the level, a vacuum would be produced, which would convert the disc into a sucker. Should the Spirula so attach itself, as Rumphius describes—('the little Post-horn' Spirula hangs to the rocks by a thin and small door, or disc, by which it sets itself fast to the rocks)—its tentacles and arms would be free to exercise their prehensile power on any passing object of food. The formal analogy to the Polype, indicated by Aristotle's name for the 'Poulpe,' would thus be carried farther in Spirula by its occasional repetition of the status of a hungry Actinia."

This power of attaching itself by means of a terminal suctorial disc—if we may rely on

* See "Annals and Mag. Nat. Hist.," January, 1879 (Plates I.—III.).

† Explanation of woodcut of Spirula:—A, dorsal wall of shell; B, ventral wall of shell; *a*, dorsal mandible of beak; *i*, ventral mandible of beak; *e*, the eye; *f*, the funnel or siphon; *d*, ventral edge of mantle; *g*, gill or branchia; *m*, retractor muscles uniting animal to shell; *c*, chambers of shell laid bare, exposing *s*, the siphuncle; *x*, the supposed sucker or disc for adhering to foreign bodies by; *b b*, the oral appendages feet or poda; *t*, one of the long tentacles.

Rumphius's statement—is peculiar to Spirula among Cephalopods; nevertheless it does, no doubt, occasionally float at or near the surface, and swim, after the manner of its kind, by the ejection of water through the funnel from its branchial sac. The animal has also a minute ink-bag, by which, if needful, to conceal its retreat by clouding the water, as in others of its class.

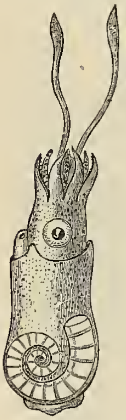
Spirula has the same number of arms (eight) and of tentacles (two) as in other Decapodous Cuttles. The arms are short and provided with minute irregularly-scattered acetabula, or suckers. The beaks are horny and well developed for the size of the animal.

The shell itself offers important points of difference from the other living members of its order, and at the same time connects it in a remarkable manner with the extinct group, the *Belemnitidæ*, on the one hand, and with the Pearly Nautilus and the Tetrabranchiata, or four-gilled division, on the other. If we compare its shell with that of the Argonaut, which is the only other convoluted internal shell in its own division, we see that the latter has no chambered portion, that it is only a simple "nidamental shell," developed in the female as a receptacle for the ova, and not in any way organically connected with the animal. In Spirula it is a complex structure, divided up into chambers, and these each penetrated by a delicate pearly tube, called a "siphuncle." The shell is, moreover, organically united to the animal, serving as the *point d'appui* of the retractor muscles of the funnel and of the head, with its locomotive and prehensile organs.

The shell is, moreover, sinistral (or left-handed), so that its relation to the soft parts of the animal is exactly the reverse of that of Nautilus. Left-handed shells in the Snail and other Gasteropoda are not uncommon, as we shall see presently.

Dr. S. P. Woodward mentions that he had formerly in his cabinet an Argonaut shell with the nucleus reversed, implying that the animal had turned right round in its shell, and then had continued to add to it in the opposite direction. This would be impossible for any mollusc whose shell was organically attached to the body of the animal.

D'Orbigny has described, under the name *Spirulirostra*, an elegant little fossil shell from the Miocene Tertiary beds of Turin, in which the upper part consists of a chambered portion (or "phragmacone") with a siphuncle, coiled into a spiral, the volutions of which are separated. This Spirula-like shell is lodged in a pointed calcareous portion, or *rostrum*, corresponding to the guard of the Belemnite. This interesting fossil thus serves as a link between the living Spirula and the fossil Belemnites; for if a guard were added to the shell of Spirula it would be converted into a form like a *Spirulirostra*.



SPIRULA AUSTRALIS. (*After S. P. Woodward.*)

It seemed as if this little Cephalopod were destined to remain long a great rarity, although so abundant in its ordinary habitat. The late lamented M. Pourtales informed the writer that he was present in 1879 in the Museum of the Jardin des Plantes, Paris, when a sea-captain offered ten specimens of the shells of Spirula to the Museum. Being told they were very common, and that it was the animal which was the rarity desired, he replied that he had taken all these ten examples alive in the open sea, with the animal, and had with his own hands cleaned them and removed the animal matter, being ignorant of their value! Doubtless [like the elegant *Euplectella aspergillum*, a single specimen of which was originally sold to the British Museum for £30, and which, when Mr. Moseley visited Abu, in the Philippines (1875), "were a 'drug' in the market, and were brought off to the ship in washing-baskets full, and sold at two shillings a dozen"] these rare little Cephalopods will be met with alive in numbers, and we shall know their complete natural history from fresh and perfect specimens; they may even be watched in our *Aquaria* in the living state, as they probably were by the old Dutch naturalist, Rumphius, in 1740.

The ten-armed section of the Dibranchiate Cephalopods approaches most nearly to the Tetrabranchiate division, not only in the fact of their more numerous feet, and the frequent development of an internal circular series of eight short labial tentacles, but also by several internal characters: as, for example, the single oviduct and detached glands for secreting *nidamentum**; the valve of the funnel;

* The material with which the eggs of the mollusca are cemented together, or enveloped, and which is secreted by the *nidamental* (or "nest-forming") gland (from the Latin *nidus*, a nest). This organ is largely developed in the female of all the Gasteropods and Cephalopods.

the laminated rudiment of a chambered shell in the Cuttle-fish; and the fully developed chambered and siphunculated shell of the Belemnites and Spirula.

ORDER II.—TETRABRANCHIATA.

FAMILY VII.—NAUTILIADÆ.

The external-shelled Cephalopods (represented at the present day by the "Pearly Nautilus" alone, but in the past by the *Nautilus, Ammonite, Goniatite, Orthoceratite,* and a host of other forms) belong to the Tetrabranchiata, or four-gilled division, and were once as extensively represented in the ancient seas of our globe as the naked or internal-shelled Dibranchiata (two-gilled) division are in the seas of to-day.

With the exception of Spirula, already described (whose pearly shell is internal), Nautilus is the only other siphonated shell now known amongst living Mollusca; the chambered character of the shell, with its siphuncle, appears, therefore, to be a unique molluscan structure, entirely confined to the Cephalopoda.

In Nautilus the inner shell-layer and septa are nacreous (composed of mother-of-pearl), the outer layer porcellanous (like porcelain). So far, then, as the composition of the shell goes, that of Nautilus is the same as in many other Mollusca. Its coloration, which, when seen floating on the surface of the water, "resembled a tortoiseshell cat" (as the sailors remarked), is good evidence of its being an external shell; as is still more the fact that it is, when living, coated with a thin layer of epidermis, or *periostracum,** which is not a living membrane, and can only be reproduced around the mouth of the shell, or where it is within reach of the margin of the mantle, which is, in most Mollusca, the true shell-secreting organ.

It is the umbonal † portion of bivalve shells and the spires of univalves which first become eroded and injured; and one object, no doubt, in the formation of septa, or partitions, in all shells is to shut off the damaged and untenantable part of their abodes.

It is almost certain that the true "Pearly Nautilus" (*Nautilus pompilius*), as well as the "Paper Nautilus" (*Argonauta argo*), was known to the father of natural history, Aristotle (B.C. 350), for after describing the Argonaut, he says :—"But the other genus is in a shell, like a Snail; it never quits its shell, but exists after the manner of a Snail, and sometimes outwardly extends its arms."

No other notice of the Nautilus worthy of record occurs until the time of the old Dutch naturalist, Rumphius (1705), who, during his long residence at Amboyna, was enabled to procure specimens and make excellent observations thereon.

The following is a translation‡ of the account given by this early observer, whose figure of the animal, as seen when taken out of the shell, is probably still (says Mr. Moseley) the best extant :—

"When the living Nautilus floats at the surface of the water it protrudes its head with all the tentacles out, and spreads those out in the water, keeping the hinder part of the curl of the shell all the while above water. On the bottom, however, the animal creeps with the other side uppermost, with the head and tentacles on the bottom, and makes tolerably fast progress. The animal remains mostly at the bottom, creeping sometimes into hoop-nets set for fish, and lobster-pots; but after a storm, when the weather becomes calm, they are to be seen floating in troops on the surface of the water. They are doubtless raised up by the waves caused by the storms. It follows that they keep themselves together in troops on the bottom also. The floating, however, does not last long, for, drawing in all their tentacles, the animals turn their boats over and go down again to the bottom. On the other hand, the empty shells are frequently to be found floating or cast up on the shore, for the defenceless animals, having no operculum, are a prey to Crabs, Sharks, and Crocodiles; and therefore the shells are mostly found with the edges bitten off. Since the animal does not adhere fast to its shell, its enemies can easily drag it out, leaving the empty shell to float.

"The young of this Nautilus, not larger than a Dutch shilling, are of a clean mother-of-pearl colour within and without. The rough shell substance overgrows the mother-of-pearl only after a time, and this overgrowth commences from the foremost part of the boat."

* From *peri*, Gr., upon, and *ostracon*, Gr., a shell: the layer of animal substance, or cuticle (*cutis*, the skin), which covers the outer surface of shells.

† *Umbo, ōnis*, Lat., the boss of a shield. ‡ "D'Amboinsche Rarikit kamer door": G. E. Rumphius, Amsterdam (1705).

[Shells in this state are believed to have lost their true coloured shell-layer by the solvent action of the gastric juice of the Dolphin's stomach, from which most, if not all, of the young shells of the Pearly Nautilus are usually obtained by collectors.]

"The Nautilus is found in all the Moluccan Islands, and also around the Thousand Islands off Batavia, in Java, yet mostly only the empty shells are met with, for the animal is seldom found unless it creeps into the lobster-pots. The animal is used for eating, like other 'Sea-cats'; but it is somewhat harder in flesh and more difficult of digestion. The shell is in much greater request for the manufacture of the beautiful drinking vessels so well known in Europe."

Dr. Bennett says that the natives of New Holland dive for *Nautilus macromphalus*, and also take it in fish-falls baited with an *Echinus*, whilst the Fijians trap *Nautilus pompilius* with a "Rock-lobster" for bait.

Mr. Moseley * writes:—"In dredging off Matuku Island, in 320 fathoms, on a coral bottom, some *Phorus*, *Turritellæ*, and a few other shells were brought up, as well as numerous specimens of the blind crustacean *Polycheles* and other animals, showing the fauna to be a true deep-water one, and with these a living specimen of the Pearly Nautilus (*Nautilus pompilius*). This was the only specimen obtained during the voyage of the *Challenger* of this animal, so rarely seen in the living condition by any naturalist.

"The animal was very lively, though probably not so lively as it would have been if it had been obtained from a less depth, the sudden change of pressure having, no doubt, very much disarranged its economy. It, however, swam round and round a shallow tub in which it was placed, moving after the manner of all Cephalopods, backwards: that is, with a small portion of the top of the shell just out of the water, as observed by Rumphius. The shell was maintained with its major plane in a vertical position, and its mouth directed upwards.

"The animal seemed unable to sink, and the floating of the shell as described, no doubt, was due to some expansion of gas in the interior, occasioned by diminished pressure. The animal moved backwards slowly by a succession of small jerks, the propelling spouts from the siphon being directed somewhat downwards, so that the shell was rotated a little at each stroke upon its axis, and the slightly greater area of it raised above the surface of the water. Occasionally, when the animal was frightened or touched, it made a sort of dash, by squirting out the water from its siphon with more than usual violence, so as to cause a strong eddy on the surface of the water.

"On either side of the base of the membranous operculum-like headfold, which when the animal is retracted entirely closes the mouth of the shell, the fold of mantle closing the gill-cavity was to be seen rising and falling, with a regular pulsating motion, as the animal in breathing took in the water to be expelled by the siphon. The tentacular-like arms contrast strongly with those of most other Cephalopods, because of their extreme proportional slightness, and also their shortness, though they are not shorter proportionately than those of the living Sepia. They are held by the animal, whilst swimming, extended radially from the head, somewhat like the tentacles in a Sea Anemone; but each pair has its definite and different direction, which is constantly maintained. This direction of the many pairs of tentacles at constant but different angles from the head is the most striking feature to be observed in the living Nautilus. Thus one pair of tentacles was held pointing directly downwards. Two other pairs, situated just before and behind the eyes, were held projecting obliquely outwards and forwards and backwards respectively, as if to protect the organs of sight. In a somewhat corresponding manner, the tentacular arms of the common Cuttle-fish, whilst living, are maintained in a marked and definite attitude, as may be observed in any aquarium.

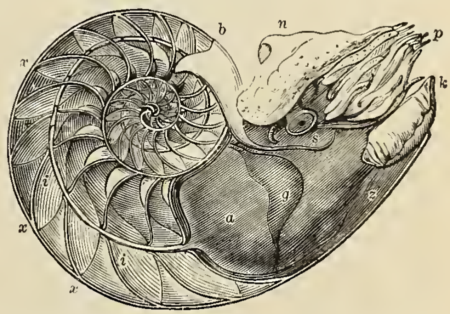
"The very great abundance of the shells of the Pearly Nautilus is most strangely contrasted with the rarity of the animals belonging to them. The circumstance is, no doubt, due to the fact that the animal is mostly an inhabitant of deep water. The shells of Spirula similarly occur in countless numbers on tropical beaches, yet the animal has been procured only two or three times. We obtained one specimen during our cruise, which had evidently been vomited from the stomach of a fish. I expect that both Nautilus and Spirula might be obtained in some numbers if traps, constructed like lobster-pots and baited, were set in deep water off the coasts where they abound in from 100 to 200 fathoms. Nautilus is occasionally caught, both at Fiji and the New Hebrides, in this manner,

* H. N. Moseley, F.R.S.: "Notes by a Naturalist on H.M.S. *Challenger*," pp. 296—300.

in comparatively shallow water, and the animals were so taken in the time of Rumphius, at the end of the seventeenth century. Traps seem never to have been tried for them in deep water. The fact that the living Nautilus was obtained from 320 fathoms shows that it occurs at great depths. It is probably a mistake to suppose that it ever comes to the surface voluntarily to swim about. It is probably only washed up by storms, when injured perhaps by the waves. The living specimen obtained by us seemed crippled, and unable to dive, no doubt because it had been brought up so suddenly from the depths of the sea."

The shell of the Nautilus is involute or discoidal, and has but few whorls. The siphuncle, instead of being placed near the inner margin of the convolutions, is nearly central. In the recent Nautili the shell is smooth, but in many fossil species it is corrugated, like the patent iron-roofing so remarkable for its strength and lightness. The umbilicus is small or obsolete in the typical Nautili, and the whorls enlarge rapidly. In the Palæozoic species the whorls increase slowly, and are sometimes scarcely in contact. The last closed chamber is frequently shallower in proportion than the rest.

In the recent Nautilus the mandibles are horny, but calcified to a considerable extent; they are surrounded by a circular fleshy lip, external to which are four groups of labial or lip-tentacles, twelve or thirteen in each group. They appear to answer to the buccal membrane of the Calamary. Beyond these, on each side of the head, is a double series of arms, or branchial tentacles, thirty-six in number. The dorsal pair are expanded, and unite to form the hood, which closes the aperture of the shell, except for a small space on each side, which is filled by the second pair of arms. The tentacles are lamellated on their inner surface, and are retractile within sheaths, or "digitations," which correspond to the eight ordinary arms of the Cuttle-fishes, their increased numbers being indicative of a lower grade of organisation. Besides these, there are four ocular tentacles, one behind and one in front of each eye. They seem to be instruments of sensation, and resemble the tentacles of Doris and Aplysia. On the side of each eye is a hollow plicated process. This process bears the external ears. The cavity leads to the auditory capsule, along a passage lined with a glandular membrane. The respiratory funnel is formed by the folding of a very thick muscular lobe, which is prolonged laterally on each side of the head, with its free edge directed backwards into the branchial cavity; behind the hood it is directed forwards, forming a lobe, which lies against the black-stained spire of the shell. Inside the funnel is a valve-like fold. The margin of the mantle is entire, and extends as far as the edge of the shell; its substance is firm and muscular as far back as the line of shell-muscles and horny girdle, beyond which it is thin and transparent. The shell-muscles are united by a narrow tract across the hollow occupied by the involute spire of the shell, and are thus rendered horse-shoe shaped. The siphuncle, according to Owen, is vascular. It opens into a cavity containing the heart (pericardium), and is most probably filled with fluid from that cavity.



INTERIOR OF THE SHELL OF PEARLY NAUTILUS, SHOWING THE LAST CHAMBER TO WHICH THE ANIMAL IS FIXED.

a, Mantle; *b*, Dorsal Fold; *g*, Shell-muscle; *ii*, Siphuncle; *k*, Funnel; *n*, Hood; *p*, Tentacles; *s*, Eye; *x*, Septa; *z*, Last Chamber.

With respect to the purpose of the air-chambers, much ingenuity has been exercised in devising an explanation of their assumed hydrostatic function, whereby the Nautilus can rise at will to the surface, or sink on the approach of storms to the quiet recesses of the deep. Unfortunately for such poetical speculations, the Nautilus appears on the surface only when driven up by storms, and its sphere of action seems to be undoubtedly on the bed of the sea, where it creeps like a Snail, or perhaps lies in wait for unwary crabs and shell-fish, like some gigantic Sea Anemone, with outspread tentacles. The specimen dissected by Professor Owen had its crop filled with fragments of a small crab, and its mandibles seem well adapted for breaking such shells as those of Crustacea, Echini, and Mollusca.

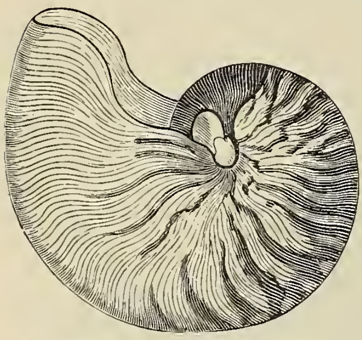
Mr. Frederick Edwards* says:—"It is obvious, therefore, that the hydrostatic balance would be destroyed if any one of the deserted chambers were so injured as no longer to act as a float."

In Woodward's "Manual of the Mollusca" we find it also stated that "the use of the air-

* In his "Monograph of the Eocene Cephalopodous Mollusca" (Palæontographical Society, 1849, p. 12).

chambers is to render the whole animal and shell of nearly the same specific gravity with the water in which it lives." But no such buoy would be required for a bottom-feeder; indeed, it would prevent it from remaining below. On the contrary, the facts of the case tend to show that, like the "water-Spondylus," the chambers were filled, or partially filled, with sea-water, which must find its way into the chambered portion of the shells, by endosmose, through its pores by the great pressure existing at the depth at which the Nautilus is found (200 to 300 fathoms), thus displacing the air in spite of the animal. Even at a depth of from twenty to thirty fathoms the pressure of such a column of water would equal more than six atmospheres—how much more, then, at three hundred fathoms?

Mr. George Bennett, M.R.C.S., F.L.S., through whom Professor Owen obtained the first specimen of the animal of the Pearly Nautilus described by him in 1832, states:—"On laying carefully open that portion of the shell which contains the chambers, it was found to contain water, which of course immediately escaped."



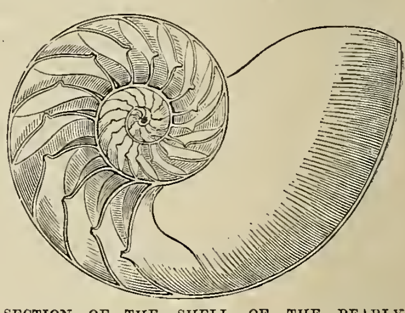
EXTERIOR OF THE SHELL OF THE PEARLY NAUTILUS.

The writer, in 1870, had an opportunity of opening the chambered portion of the shell of a *Nautilus umbilicatus*, which had been preserved, with the animal, in spirits of wine. The last three chambers preceding that occupied by the animal were laid bare for a distance equal to half the circuit of the shell-whorl.

The siphuncle (when the chambers were laid open) was quite entire, and sheathed in a thin nacreous investment, which, however, attains considerable thickness near to each septum.

The chambers contained a large quantity of fluid, of which I did not specially take note at the time; but on reading Professor Owen's memoir, I have no doubt that its presence in this, and also in Mr. Bennett's specimen, was not abnormal (as I had supposed), but in accordance with the natural state of all camerated shells, and that it is a misnomer any longer to call them "air-chamcers."

Professor Owen writes as follows:—"From the extremity of the sac is continued a small tubular membranous process, which passes through the siphonic apertures in the septa of the shell, and is continued, there is reason to believe, to the innermost chamber. This tube has been surmised to be tendinous or muscular; but the attachment of the shell to the soft parts proves to be effected by much more adequate means. Rumphius appears to have been acquainted with its true structure, for he calls it an artery (*een langen ader*), and, in fact, within the external thin membrane is included a small artery or vein. How far these vessels are continued within the chambered portion of the shell, or in what manner they are distributed, remains for some future investigation; for in the present instance the only part of the shell that was preserved was the small portion adhering to one of the horny tendons, and the membranous tube had been ruptured in removing the animal at a few lines distance from its origin at the mantle. This tube appears to be contracted at its origin, and its diameter at the wider part is one line and a half."



SECTION OF THE SHELL OF THE PEARLY NAUTILUS, SHOWING THE BODY-CHAMBER AND THE SEPTA GIVING PASSAGE TO THE SIPHUNCLE.

Even admitting that the purpose of the siphuncle is to maintain the vitality of the shell during the long life of the animal, it seems difficult to imagine how this vitality can be maintained in a non-vascular body. If the siphuncle be a means for repairing the shell, we ought to find some connection between it and the shell, but such does not exist; indeed, the fossil species have in many instances enormously thick pearly or shelly siphuncles.

In fact, when the shell of Nautilus, or of any other Mollusc, is once formed, it is extra-vascular, or dead matter, in the same sense that nails and hoofs and hair of higher animals are so, being incapable of repair, save at the growing end, or where in contact with the shell-secreting mantle.

In the specimen of *Nautilus umbilicatus* already referred to, which I had the good fortune to examine, I observed the thin pellicle of membrane, described by Professor Owen, lining the chambers;

but as it is only a film, and presents no structure under the microscope, I conclude it to be deposited or left behind by the secreting surface of the mantle when the nacreous septum was formed. And this opinion is strengthened by Dr. Carpenter's statement, "that in every distinct formation of shell-substance there is a single layer of membrane," and "that this membrane was at one time a constituent part of the mantle of the mollusc."

The nacreous covering of the siphuncle was entire, and on removal it was found to enclose a simple membranous tube, composed of an extension of the periostracum, and exhibiting no structure, even under a one-tenth objective.

As I could not detect any artery or vein, I conclude that they probably do not extend beyond the first chamber. This view coincides with Professor Owen's statement that "neither the contents nor the vital properties of the siphon are, however, yet known; an artery and vein are assigned for its life and nutrition, and to extend a low degree of the same influence to the surrounding shell." But the structure of the membranous siphon, in the specimen from which I had the opportunity of examining it in a recent state presents, beyond the first chamber, an inextensible and almost friable texture, unsusceptible of dilatation; it is also coated beyond the extremity of the short testaceous siphon with a thin mother-of-pearl deposit.

We know that the body of the animal in Nautilus is attached to the shell by means of the two adductor muscles, and by a continuous horny girdle around the mouth of the body-chamber. The suggestion, therefore, of Von Buch, that the function of the siphuncle was to hold the animal into its shell loses much of its significance. But may it not have been the most important point of attachment between the animal and its shell in the earlier forms of the Tetrabranchiata? In support of this view we may notice that in the fossil Nautili the siphuncle was a shelly tube of considerable size and thickness, whilst in *Orthoceras* it attained to a great magnitude—as, for instance, in the genus *Huronia*, in which it is as large as a human vertebral column. In *Actinoceras*, *Gyroceras*, and *Phragmoceras* the siphuncle is also very large, and contains in its centre a smaller tube, the space between the two being filled up with radiating plates, like the lamellæ of a coral.

Speaking of the connection between the *Nautilus pompilius* and its shell, Professor Owen says:—"A third point of attachment is to the bottom of the shell, by the posterior extremity of the mantle, which probably presents a conical form in the embryo Nautilus." If, then, the siphuncle in the young stage forms the main point of attachment between the animal and its shell, we may reasonably argue that the siphuncle in the adult Nautilus is simply the evidence of an aborted embryonal organ, whose function is now fulfilled by the shell-muscles, but which, in the more ancient and straight-shelled representatives of the group (the Orthoceratites), was not merely an embryonal, but an important organ in the adult.

The formation of the septa is undoubtedly due to the constant onward growth of the shell season by season, and in the female to the periodic development of the ova within the ovary of the parent, producing, when discharged from the shell, a corresponding reduction in the size of the soft parts of the animal, and necessitating an equal reduction in the space of the body-chamber. In youth these septa represent periods of rest in shell-growth, in middle life periods of fertility, in age reduction of the shell to suit the reduced size of the Mollusc. In this respect the septa in Nautilus agree with those found in other Mollusca. "The line of attachment of both the muscles and the cincture progressively advances with the growth of the animal. A certain portion of the fundus of the shell thus becomes vacated, and the Nautilus commences the formation of a new plate for the support of the part of the body which has been withdrawn from the vacated shell. The formation of the plate proceeds from the circumference to the centre, and there meeting the conical process of the mantle, which retains its primitive attachment, the calcification is continued backwards for a short distance around the process which now forms the commencement of the membranous siphon, and requires the partial protection of the calcareous tube. An air-tight chamber is thus formed, traversed by the siphon, which perforates its anterior wall or septum. By a repetition of the same process a second chamber is formed, included within two perforated septa; and similar, but wider, partitions continue to be added concurrently with the formation of the new layers, which extend and expand the mouth of the shell, until the animal

acquires its full growth, which is indicated by the body having receded for a less distance from the penultimate septum before the formation of the last septum is begun." (Owen.)

If we will only bear in mind this fact, that the animal of the Oyster and the Nautilus is compelled by the constant, though almost imperceptible, growth of the mouth or border of the shell to which it is attached by the margin of its mantle to move forward in its habitation, and that its hinge-ligament and shell-muscles are absorbed behind and added to in front, to accommodate themselves to the onward growth of the shell-border, of necessity, therefore, the animal cannot let go its muscular or its siphuncular point of attachment to the old septal surface until the new one is made ready; hence the dipping down from layer to layer of the Oyster's shell-muscle; hence also the curious funnel-like tubes in *Nautilus* (*Aturia*) *zic-zac.*

Although the Tetrabranchiate division of Cephalopods is only known by a single living genus, the Pearly Nautilus, in Silurian times it was represented by thirty-four genera and above 1,600 species. The shell in all the animals of this division is, geometrically speaking, an extremely elongated cone, either straight or variously folded and coiled. The Palæozoic species, of which *Orthoceras* is the type, had simple sutures, not complex, as is the case with the Secondary forms; but they underwent the same variations in curvature between straight in *Orthoceras*, bent on itself in *Ascoceras*, curved in *Cyrtoceras*, spiral in *Trococeras*, discoidal in *Gyroceras*, produced discoidal in *Lituites*, and involute in *Nautilus*.

All the shells, as in Nautilus, are furnished with a siphuncle, sometimes having the appearance of a string of beads, at others like the vertebral column of some higher animal. The largest British *Orthoceras* does not exceed five to six feet in length, but they have been met with in America ten to twelve feet long, and of proportionate bulk. From faint indications of colour-bands it seems probable the shell was not an internal one, like the Belemnite, but rather like the modern Nautilus, external to the soft parts of the animal. In the *Goniatites* and the *Ammonites* the septa of the shell have most complex borders, which leave their impress upon the shell, and are called its sutures. They are highly ornamental in the Ammonites, often resembling the foliage of plants in pattern. The siphuncle, which is mostly central in *Orthoceras*, is marginal in *Ammonites*, running along the middle of the keel of the shell.

In the recent Nautilus the two "dorsal" arms are soldered together and expanded into a thick hood or operculum of tough and rugose epidermis. In the fossil Ammonites calcareous matter is added, thus forming a bi-lobed shelly operculum, or lid, which closely fits the mouth of the shell in many of the species, and has been found *in situ* in a specimen of *Ammonites subradiatus* from the Inferior Oolite of Dundry, near Bristol. One species from the Lias has a horny operculum. Thus we have in *Nautilus* and *Ammonites* a perfect analogy to the Gasteropoda, in which there are Snails without opercula, Snails with horny opercula, and others with shelly opercula.

More than 700 species of *Ammonites* have been described, extending from the Carboniferous of India to the Chalk, and they were of world-wide distribution.

In the Chalk a number of Cephalopodous shells have the appearance of having become "uncurled," and assumed fantastic forms of growth, as straight, folded in two, hooked, spiral, open spiral, trumpet-shaped, discoidal in the young state, and uncurled in later life.

The Tertiary Nautili differ but little from their modern representatives, save one form, named *Nautilus* (*Aturia*) *zic-zac*, from the curious bent pattern of the septal partitions. In this form the siphuncle is not continuous, but is made up of a series of rather thick funnel-shaped nacreous tubes fitting one into another. This species is repeated, in a modified form, in the Secondary rocks, and by what is believed to be a Palæozoic representative in New Zealand.

HENRY WOODWARD.

CHAPTER II.

THE GASTEROPODA.

"Shell-fish"—Uses of the Shell—The Kinds of Shells—Economical Uses of the Mollusca in the Earliest Period and in the Present Day—Form and Growth of Shells—Parts of a Shell—Order I. PROSOBRANCHIATA: (*a*) SIPHONOSTOMATA—Siphonated Gasteropoda—Family I. STROMBIDÆ, "Wing-shells"—2. MURICIDÆ—Murex, the Source of the Celebrated "Tyrian Purple" Dye—"Mitre-shells"—Fusus, the "Red Whelk"—Whelks used for Food—Hemifusus, one of the Largest of Living Shells—3. BUCCINIDÆ—Buccinum, "Triton's Shells"—The "Dog Whelk," Nassa—Purpura—Its Dye—How it Tackles its Prey—Magilus Boring in Coral—The Harp-shells—The Olives—4. CASSIDIDÆ—Cassis—"Cameo-shells"—Triton—Use of the Shell as a Trumpet—Growth of Sea Snails—5. CONIDÆ—The "Cones"—Their Beauty and Commercial Value—Conus Gloria-maris—Terebra, the "Augur-shell"—6. VOLUTIDÆ—Rarity of the Volutes—7. The CYPRÆIDÆ—Cowries—Richness of their Colour and their Value—Past and Present Prices of Specimens of Rare Shells—The Money Cowry—Cuttle-fishing with Cowry Bait—Shells as Articles of Ornament in Dress—Ovulum.

CLASS II.—GASTEROPODA.

INTRODUCTION.

AMONG the various natural objects which the ingenuity of man in all ages has converted into articles of use or ornament, both in savage and civilised life, none have attracted a greater amount of attention, or have been more in request, than the shells of Mollusca, especially sea-shells. Their bright colours and diversity of form are amongst their chief charms to the uninitiated; whilst to the student of natural history they offer ample materials for scientific research.

The shell in the Mollusc may be regarded as a hardened, or calcified, portion of the mantle, specially provided (like the enclosing ribs of the vertebrata) to afford protection to the breathing organs and heart. Indeed, when reduced to a mere rudiment, as in slugs, such as *Limax* and *Testacella*, or in the Marine Snail, *Carinaria*, &c., it forms only a hollow cone or plate protecting these organs. This structure (which has sometimes been called a pneumo*-skeleton) is so characteristic of the Mollusca as to have obtained for them the title of *Testacea*,† and the common name of "shell-fish" very well expresses the leading feature in the group. Nevertheless, in several families, the shell is either wanting altogether, or is internal, or so rudimentary that it would never be popularly recognised as a shell. When fully developed, the shell of the Mollusc subserves to protect the soft parts of the animal from injury, and the animal itself from the attacks of enemies; and in some of the Gasteropoda from those variations of temperature and moisture to which the terrestial species are peculiarly exposed.

Shells are often called the "habitations" of fishes, or of marine animals, or Snails. Every one has seen the device of a Snail, with the motto, "always at home," on juvenile letters. The quarrymen of the Cotswold Hills go so far as to call some fossil shells snail-houses, the same epithet which they apply to the empty shells of the common Garden Snail. The term is not quite correct, for they are more properly skeletons, and we do not "inhabit" our bones, though Byron calls the skull a "tenement," and "the palace of the soul." Nevertheless, the expression is sufficiently indicative of the sense in which it is popularly used, and may pass muster without any further challenge on our part.

One afternoon last summer we visited the fish-house of the Zoological Gardens, and paused to watch the manœuvres of a Hermit Crab housed in a whelk-shell. Just then a lady of distinguished appearance called the attention of her friends to the same truculent animal, and expressed her lively satisfaction at having become acquainted with "the creatures which made that kind of shell." We hope before long that our readers will attain to a better acquaintance with the original fabricator of that common object of the shore, and to show how the forms and patterns of shells are suited to the wants and welfare of their proper owners.

It may be seen at a glance that many shells are bivalves,‡ like the Oyster and Cockle, while a few called "Chitons" are multivalve;§ but the great majority are single-valved, or univalves, and sometimes tent-shaped, like Patella, or tubular, as in *Aspergillum* and *Dentalium*, *Vermetus*, and

* From *pneuma*, the breath. † From *testa*, a shell.
‡ Two-valved. § Many-valved.

Siliquaria; but for the most part spiral, though exhibiting an endless diversity in their proportions as well as in their sculpturing and colour.

All insects, crabs, and other articulate animals are symmetrical, having the organs in pairs, *i.e.,* the right side like the left. In Corals and Star-fishes this two-sidedness is usually disguised by a radiate arrangement of the parts. But in Snails the symmetry of the eyes, tentacles, and other organs of the head is lost in the body of the creature. Instead of a double heart and two series of gills, these organs are single, and placed on one side. When on the left side, the growth is from left to right, to provide space, but in shells which are symmetrical, like the Pearly Nautilus, the Keyhole Limpet, and the *Ampullaria,* the gills are developed symmetrically on each side, or nearly so.

The tendency to grow in a spiral form is very characteristic of the class Mollusca. Some writers have accounted for it in a very matter-of-fact way. "Molluscous animals are long and worm-like, therefore Nature has coiled them up, that their tails may not be an incumbrance to them." It is easily ascertained that the Snail has a small spiral shell when it first quits the egg, and the young Whelk may be examined while still a prisoner in the same capsule with its brothers and sisters. The convenience of the arrangement is obvious, and that may be sufficient for us at present, but the time is coming when naturalists will desire to look more closely into these things.

How happens it that the embryo Snail, coiling itself up closely in its narrow cell, almost always takes a direction from left to right, following the course of the sun, and forming a dextral spiral, or right-handed shell, like an ordinary screw? Such a course is not absolutely necessary, neither is it accidental. A few Whelks and Garden Snails—perhaps one in ten thousand—are left-handed, and certain kinds of Whelks and Land Snails are as frequently reversed as right. The greater part of the genus *Clausilia* (numbering upwards of two hundred species) is reversed. The species of the genera *Physa* and *Triforis* appear to be always reversed. All the specimens of *Fusus contrarius,* so abundant in the Red Crag, and also found living in Vigo Bay, on the coast of Spain, are left-handed. But after all these latter are the exceptions. Every one familiar with garden plants will have noticed that the hop turns round its pole in one direction, going to meet the light, while the scarlet-runner takes an opposite course, as invariably as the sun it follows.*

Shells owe their variations in form to a number of circumstances. Those which assume a spiral, vary in being either turbinated or discoidal in their growth, and again, in the infinite gradations between the extremes of these two. The shape of *Conus* is an inverted triangle, that of the "telescope shell" (*Cerithium telescopium*) is trapezoidal, and so on. The turbinated shells again merge into forms in which the whorls become detached with age, as in *Vermetus;* or a nearly straight tube, like *Dentalium.* The discoidal shells graduate into forms having fewer and fewer convolutions, and wider and simpler mouths, until at last, in forms like the Limpet, all spirality is lost, and we have only a tent-shaped cover.

At almost the earliest period in which we discover evidence of the existence of man, we find the primitive races dwelling upon the sea shore, and subsisting largely upon Mollusca; leaving at one point shell-mounds of oyster-valves, associated with rudely-fashioned flint knives, employed in opening them; at another, the broken fragments of turbinated univalves, and the round stone hammers used in crushing the shell to procure the *bonne-bouche* it enclosed. Nor did the mere cravings of hunger impel them to seek shell-fish as articles of food, for in the limestone caverns of France and Belgium numerous remains of shells of Mollusca have been met with, pierced with holes for the purpose of attaching them to some article of dress or head-gear.

Among the aborigines of the present day, in whatever region of the earth they dwell, the same economic uses of Mollusca prevail, and their practices serve to throw much light upon the fragmentary remains of their pre-historic ancestry.

The second class of Mollusca, called *Gasteropoda*†—from the fact that the animals included in it habitually creep or glide by the successive expansion and contraction of the under side of the body, which forms a broad muscular foot—is well exemplified by the common Garden Snail. If one of these be watched through a window-pane in the act of creeping on the surface of the glass, the muscular movements of the foot may be seen following one another in rapid wave-like rhythmical succession.

* Unluckily, the botanists have chosen to reverse the terms employed in mechanics, and call the spiral of the hop right-handed.

† *Gaster,* belly; *pous,* foot.

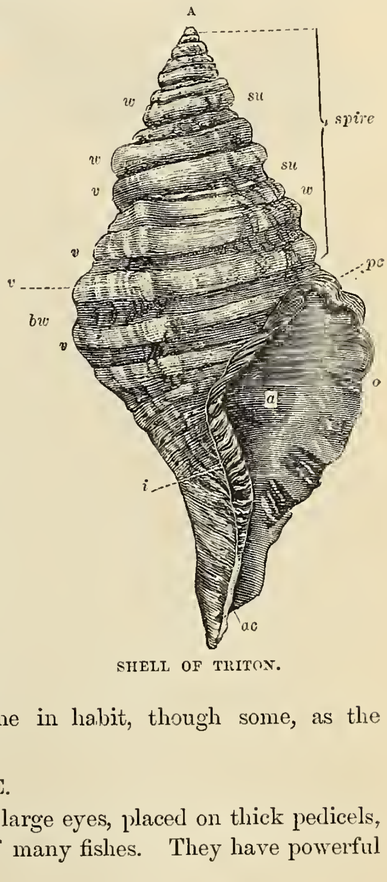
Nearly all Gasteropods are unsymmetrical, the body being coiled up spirally, having the breathing organs on the right side developed and those on the left absent. A few are like the Cephalopoda in being bilaterally symmetrical, as *Chiton* and *Dentalium*, in which the gills and ovaries are found on each side. With a few exceptions, in which the young Snails are born like their parent, the greater part deposit eggs, either in the water or in damp situations on the land. All are provided with a shell when first hatched, but this (in some genera) is found to become concealed by growth in the adult, or disappears altogether in later life.

The creeping Snails are, like the Cephalopoda, divided into two natural groups by their breathing organs—in the one they breathe air, and are hence called *Pulmonifera*,* in the other the gills are bathed in water, and they are named *Branchifera.*

Before proceeding further, it may be well if we clearly understand what are "the points" about a univalve shell, so that in enumerating the salient features of each genus our readers may comprehend and follow us in these descriptions.

The subjoined lettered figure of a shell of the genus *Triton* may serve to indicate, better than whole chapters of description, by what terms each portion of the shell is named.

This shell may be described as fusiform :† the apex (A) mamillated ; ‡ the whorls (*w*) ventricose, § strongly ribbed or corrugated, with non-continuous varices ‖ (*v*), and distinct sutures ¶ (*su*) ; the columella ** (*i*) is denticulated ; †† the outer lip (*o*) is internally plicato-dentate ; ‡‡ the anterior canal (*ac*) is elongated ; the body-whorls (*bw*) are large ; the aperture (*a*) ovately-elliptical.



SHELL OF TRITON.

ORDER I.—PROSOBRANCHIATA.§§

In the first order of Gasteropoda, called *Prosobranchiata* by Milne-Edwards, the gills are pectinated, or comb-like, and are placed in advance of the heart. The soft parts are protected by a shell into which the body of the animal can usually be withdrawn. The eye pedicels and the tentacles, or feelers, are on the same stalk.

Division a.—SIPHONOSTOMATA.‖‖—The proboscis is long and retractile, and the breathing chamber is provided with a tube, or siphon, to convey a fresh current of water to the comb-like gills. The members of this section are carnivorous and marine in habit, though some, as the "Strombs," are carrion-feeders.

FAMILY I.—THE STROMBIDÆ.

The *Strombidæ*, or "Wing-shells," are very active; they have large eyes, placed on thick pedicels, which are more perfect than those of other Gasteropods, or even of many fishes. They have powerful lingual teeth of a type peculiar to the carnivorous Sea Snails.

The Strombs (*Strombus* ¶¶) generally have a widely-expanded outer lip with an elongated aperture, lobed above and sinuated near the notch of the anterior canal. The whorls of the spire are often covered with tubercles or spines ; and the spire of the shell is usually short.

* *Pulmo*, a lung ; and *fero*, I bear.

† Spindle-shaped, pointed at both ends : from *fusus*, Lat., a spindle.

‡ From Lat., *mamilla*, a teat, a rounded summit.

§ From Lat., *ventricosus*, inflated.

‖ Lat., *varix*, a swollen vein ; in reference to the periodic mouths or ridges on the whorls of some shells, marking rests in growth.

¶ Lat. *sutura*, a seam ; the point where two whorls of a spiral shell are united.

** Lat., *columella*, a small column or pillar ; the axis of a spiral shell, around which the whorls of the shell grow.

†† From Lat., *dens*, a tooth ; hence denticulated, bordered with small teeth.

‡‡ Lat., *plica*, a fold, and *dens*.

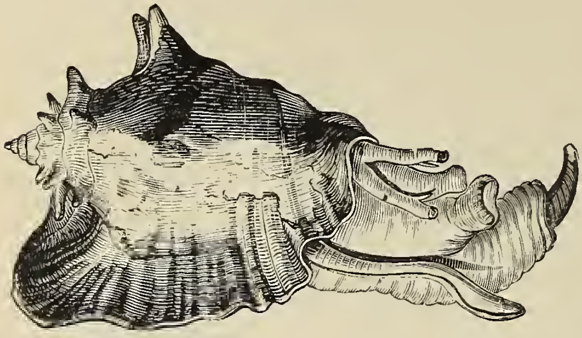
§§ *Proson*, in front ; *branchiata*, gilled.

‖‖ From *siphon*, a tube, and *stoma*, a mouth.

¶¶ From *strombos*, a top.

The great *Strombus gigas*, the "Fountain-shell" of the West Indies, is one of the largest of living shells, weighing sometimes four or five pounds. As it becomes old the animal fills up its apex and spines with solid shell matter.

Immense quantities are annually imported from the Bahamas for the manufacture of cameos, and for the porcelain works. Prof. T. C. Archer states that 300,000 were brought to Liverpool alone in 1850. Strombs are common to the West Indies, the Mediterranean, Red Sea, Indian Ocean, and Pacific. Their favourite resort is on reefs at low water, down to ten fathoms depth. Sixty species are known living, and many species occur fossil in the Miocene Tertiaries of Europe.

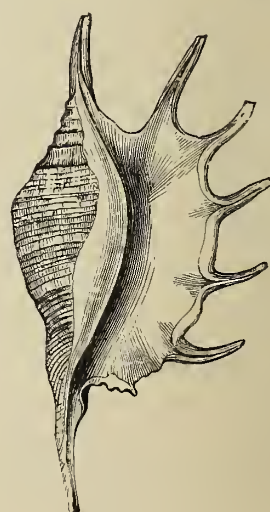


SHELL OF STROMBUS GIGAS, WITH THE ANIMAL.

"Though the natives of the Antilles possessed few natural advantages over the inhabitants of the volcanic and coral islands of the Pacific, yet the abundance of large and easily-wrought shells invited their application to many useful purposes, and accordingly, when first visited by the Spaniards, the large marine shells, with which the neighbouring seas abound, constituted an important source for the raw material of their implements and manufactures. The great size and the facility of workmanship of the widely-diffused *Pyrulæ*, *Turbinellæ*, *Strombi*, and other shells have indeed led to a similar application of them among uncivilised races wherever they abound. Of such, the Caribs made knives, lances, and harpoons, as well as personal ornaments, while the Mollusc itself was sought for and prized as food. In Barbadoes, the *Strombus gigas* still furnishes a favourite repast, and numerous weapons and implements made from its shells have been dug up on the island. Plain beads formed from the columellæ of *Strombus gigas* have been found in the ancient graves of Tennessee, Kentucky, and Indiana. The columellæ were found worked to a uniform thickness, perforated through the centre, and in nearly all stages of manufacture, to that of perfect beads and links of much prized wampam."*

In the "Scorpion-shell" (*Pteroceras*) † the outer lip is produced in the adult shell into several long claws, one of which joins to the spire of the shell and forms the posterior canal. On account of its singular form this has been christened the "Spider," or "Scorpion-shell."

The genus *Rostellaria*,‡ or the "Spindle-stromb," is marked by having a very much elongated spire and long canals to its shell; the posterior one runs up the surface of the spire; the outer lip is sometimes expanded. In the great *Rostellaria ampla*, from the Middle Eocene of Barton, Hants, the adult animal puts forth a widely-expanded lip, as broad as one's hand, forming an immense "flange," or ear. Five species are found in the Red Sea and on the coasts of Borneo, India, and China.



PTEROCERAS LAMBIS.

FAMILY II.—MURICIDÆ.

The *Muricidæ* are extremely varied in form, having three rows of many-coloured spinous fringes, produced at nearly coincident intervals on each whorl of the shell, and becoming longer with age. "Venus' Comb" (*Murex tenuispina*) is an instance of this, the canal of the shell being produced to twice its length, and fringed with three rows of long and slender spines, slightly curved like the teeth of a harrow. In *Murex adustus* the spines are extremely picturesque, reminding one of a branching fir-tree. The Murices form only one-third of a whorl annually, ending in a *varix*. Some species form intermediate varices of lesser extent.

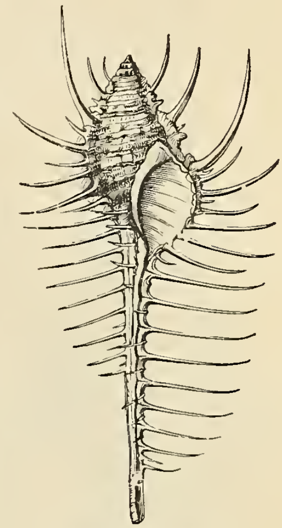
One very abundant form, common on our coast and around the Channel Islands, is called the "Sting-winkle" by the fishermen, who say it makes round holes in the other shell-fish with its

* Daniel Wilson's "Pre-historic Man."

† From *pteron*, a wing; and *keras*, a horn.

‡ *Rostellum*, a little beak.

beak. The lingual teeth of *Murex* seem well fitted for thus boring through the shells of other Molluscs on which all these sea snails are predatory.* The dye used in the manufacture of the celebrated "Tyrian purple" of the ancients was obtained from certain species of *Murex*. The small shells were bruised in mortars, and the animals of the larger ones were taken out. Heaps of broken shells of *Murex trunculus* and cauldron-shaped hollows in the rocks may still be seen on the Tyrian shore. (Wilde.) M. Boblaye noticed that on the coast of the Morea there is similar evidence of the employment of *Murex brandaris* for the same purpose. One hundred and eighty living species have been noticed; they are of world-wide distribution.


MUREX TENUISPINA.

The *Muricidæ* not only possess the power of forming, but also of dissolving parts of their shells, and they use it in removing those external spines which, in the onward and continuous growth of the shell, would interfere with the comfort and convenience of the animal.

Columbella is the name given to a genus of small but prettily-marked shells, living in shallow water, on sandy flats, or congregating on stones, having a long narrow aperture, a thick outer lip, dentated within, the inner lip being crenulated and the operculum very small. About 200 species have been described, all being sub-tropical and widely distributed. The *Columbella mercatoria* of the West Indies was formerly used by the natives as "wampum" for barter or exchange.

The genus *Fasciolaria* (from *fasciola*, a band) is an elegantly-formed shell, with round or angular whorls (like a *Fusus* in shape), having bands of colour running down its sides; the inner lip has several oblique folds on it. The operculum is claw-shaped. Like the preceding genus, some species of *Fasciolaria* attain a very large size. The *Fasciolaria gigantea* of the South Seas attains a length of nearly two feet.


MITRA EPISCOPALIS.

The genus *Mitra* (the "Mitre-shell") has an elevated spire, with an acute apex; the shell is thick, the aperture small, and notched in front, the columella being obliquely plaited, and the operculum very small. The animal has a very long proboscis, and when irritated it emits a purple liquid, having a nauseous odour. Its bright colour-bands and ornamentation have led to the names of "Mitre-shell," "Bishop's Mitre," "Tiara," &c. This is a very abundant form. Three hundred and fifty species are known ranging from low water to a depth of eighty fathoms. They are mostly denizens of the tropical seas. Many of them must be very abundant, and yet a scientific person who only invests shillings in the purchase of shells may go on for twenty years and find himself only in possession of a few species, and of one common and brilliantly-coloured sort—the *Mitra episcopalis*. The most beautiful of the *Mitras* is properly called *regina*, but the rarest is *M. stainforthii*, valued at £10, of which Mrs. De Burgh possesses the original example. The same lady has the only specimen in England of the equally valuable (but not equally beautiful) *M. zonata*, which was brought up by the lead of a sounding-line from deep water off Nice, and described by Marryat in the *Linnean Transactions* of 1817.

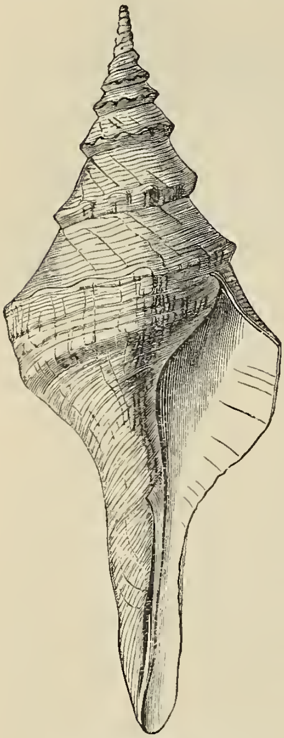
The *Turbinella* (or "Top-shell") is a very thick, solid shell, with a short spire and a long canal. On the columella are several transverse folds. On the coast of India, China, Siam, Tranquebar, and Ceylon the Shank-shell (*Turbinella pyrum*) is carved by the natives, and placed in their temples. The reversed variety is held sacred by the Cinghalese, and from it the priests administer medicine to the sick. Another species is called the "Pap-boat" (*Turbinella rapha*). "It is used," says Sir J. Emerson Tennent, "on the Malabar coast (when scooped out internally and carved externally) to contain the sacred oil which is employed in anointing their priests."

The "Spindle-shell," *Fusus* (called the "Red Whelk" on the coasts of the Channel, and the "Buckie" in Scotland), is extensively dredged for the markets, being more esteemed in the north than

* For a description of the lingual teeth, or "odontophore" of snails, see p. 222.

the common Whelk (*Buccinum undatum*) as an article of food by the poorer classes. The shell is fusiform, with a many-whorled spire, and a long straight canal; the operculum is oval and curved, with the nucleus at its apex. *Fusus* has a world-wide distribution. Over one hundred species are described, many of which are sub-tropical.

The *Fusus antiquus* is extensively sold in Scotland, and also in Liverpool. It is the "Roaring Buckie," in which the sound of the sea may always be heard. Indeed, from its abundance and its size, it is very frequently used by children in the manner described in the exquisite lines of Wordsworth :—



FUSUS PROBOSCIDALIS.
(*One-sixth natural size.*)

> "I have seen
> A curious child applying to his ear
> The convolutions of a smooth-lipped shell,
> To which, in silence hushed, his very soul
> Listened intensely, and his countenance soon
> Brightened with joy ; for murmuring from within
> Were heard sonorous cadences, whereby,
> To his belief, the monitor express'd
> Mysterious union with its native sea."

The most valuable of the British univalves are some of the large Whelks; it is impossible to get a specimen of *Fusus turtoni*, even from the fishermen, for less than 30s., because it is only taken on the Scarborough coast, and there are always residents as well as visitors ready to buy it. A fine example would fetch three guineas in town. *Fusus dalei* is worth from three to five guineas; *Fusus berniciensis*, five guineas; and there are collectors who would give still more for the *Fusus fusiformis* if it could be obtained. The little *Stylifer turtoni*, found on the backs of Sea Urchins nestling among their spines, would have cost a guinea a few years ago, but has since been found in considerable numbers at Plymouth.

All the specimens of *Fusus antiquus* dredged in Vigo Bay, on the coast of Portugal, are found to be reversed (*i.e.*, sinistral, or left-handed spirals). *Fusus deformis*, found living off Spitzbergen, is also always reversed.

In Zetland, the *Fusus antiquus*, suspended horizontally by a cord, is used by the fishermen as a lamp, the canal serving to hold the wick, and the body of the shell the oil. (Fleming.)

Hemi-fusus colosseus and *proboscidalis* are two of the largest living Gasteropods. The latter has been found placed as an ornament on the graves of the aborigines in Australia. It attains a length of two feet. Some living species of *Fusus* are remarkable for the great length of the canal. This is the case in *Fusus colus*, in which it is twice as long as the rest of the shell.

The nest for hatching the fry of *Fusi* is curious in all the species. That of *Fusus norvegicus* consists of a lens-shaped bag, of an inch diameter, glued to the inside of shells. Mr. Howse says :— "The envelope is coriaceous, of a horny appearance, very transparent, smooth, glossy, and of a yellowish colour ; one of the capsules contained three, the other only two, embryos. The last were far advanced, and apparently ready to leave the case. Through the transparent covering, when first dredged, I could see them moving about, and adhering to the inner surface of the capsule by the expanded foot, the sides of which were of a faint lilac colour. The thin operculum, the flattened tentacles, the diminutive spot-like eyes of these beautiful little creatures, were also distinctly visible. The young shell is very thin, brittle, pellucid, brilliantly glossy, and of a pale amber colour, nipple-formed, and perfectly resembles the nucleus, or upper whorl, of the adult individual. Those most advanced in growth have two whorls, and are half an inch in length by a quarter in width."

The capsules of *Fusus antiquus* are smaller, and placed above each other in a heap. The young are fully formed before they leave the capsule, but the young shell, which forms the nucleus or apex of the spire of the adult, is thin, rounded, and of a totally different character : hence the curious mammillated apex observed in all the species. (Sowerby.)

FAMILY III.—BUCCINIDÆ.

The *Buccinum*,* or "Triton's shell," is the type of another family of carnivorous Gasteropoda, in which the shell mouth is notched in front, or with the canal abruptly bent back. It has excellent lingual teeth for boring into shells with, and a long proboscis-like mouth and siphon, so that when burrowing after the living bivalves on which it feeds it can protrude its mouth into their gaping valves, or drill a hole even into the shell itself, if necessary; moreover, its long siphon is thrust upwards above the mud or sand, so that the animal can at the same time breathe freely. It requires only the opportunity to study the form and habits of the animal inhabiting these snail-houses to perceive that nearly all the peculiarities in the form of shells relate to some special function or habit of life of the animals which inhabit them.

One of the most important functions to be provided for in Snails is that of respiration. In univalves, the aperture of the shell is usually found to be characteristic of the division to which the animal belongs, the mouth being entire in most of the vegetable feeders, and notched, or produced into a canal in the carnivorous families (or *Siphonostomata*). But this canal, or siphon, is respiratory in its office, and must not, therefore, always be taken as a certain and sure indication of the nature of the animal's food. Thus, for example, *Scalaria pretiosa* has a holostomatous, or perfect aperture to its shell, but is known to be carnivorous in its diet. If we refer to the Dog Whelk (*Nassa reticulata*) and the common Whelk (*Buccinum undatum*), we shall see the long incurrent siphon protruding from the canal of the shell and turned upwards. Into this tube the water passes, and enters a vaulted chamber (formed by an inflection of the mantle of the animal), which contains the pectinated, or plume-like gills. After traversing the length of the gills, it returns and escapes through a posterior siphon, generally less developed than the anterior one, but very long in *Ovulum volva*, and formed into a tube in *Typhis*. The object of the long siphon in the Whelk is to enable it to respire freely while burrowing in the sand in search of its prey—the poor defenceless *Mya*, and other bivalves.

The shell of the *Buccinum* is few-whorled, the whorls are ventricose, the aperture of the shell is large, the canal very short and bent back on the shell, the operculum is lamellar, and the nucleus is external. The *Buccinum* is characteristic of the northern seas, extending from low water to 140 fathoms. Twenty living species have been described. (See No. 2 in figure on p. 196.)

All round our coasts and on the shores of Ireland the Whelk (*Buccinum*) is dredged for the market, and is used as bait by fishermen. Many tons of them are annually consumed in the streets of the poorer parts of London.

The exterior of the shell of the Whelk is invested with a thin straw-coloured membrane, or epidermis, whose existence is scarcely recognised. Shells from a quiet soft sea-bed often have a coat like brown velvet. Many exotic *Tritons* are remarkable for their rough cuticle. All the Whelk tribe have horny *opercula*, and the pattern is often characteristic of the genus; the operculum is never spiral. Gregarious animals, such as the Whelk and Periwinkle, exhibit malformations more frequently than do others; thus we have Whelks with double opercula, others with shells repaired after injury or curiously contorted. A large percentage in particular localities are met with having the shell reversed.

The nidamental capsules of *Buccinum* are aggregated in roundish masses, and often attached to other shells, which, when thrown ashore and drifted by the wind, resemble horny corallines in appearance. Each capsule contains five or six young, which, when hatched, have each a tiny, stumpy, inflated spiral shell, very unlike the adult, of which it becomes, in course of growth, the apex.

The genus *Pseudoliva*† has a thick globular shell, with a deep spiral furrow near the front of the body whorl, and forms, like *Monoceros*, a small tooth in the outer lip; the spire of the shell is very short and the suture channelled; the inner lip is thickened so as to form a callosity; the mouth of the shell is notched in front. Six species are named from South Africa.

The genus *Halia*‡ was for many years a great puzzle to naturalists. It was only known by the existence of one or two shells in collections, and its habitat was lost. In general form

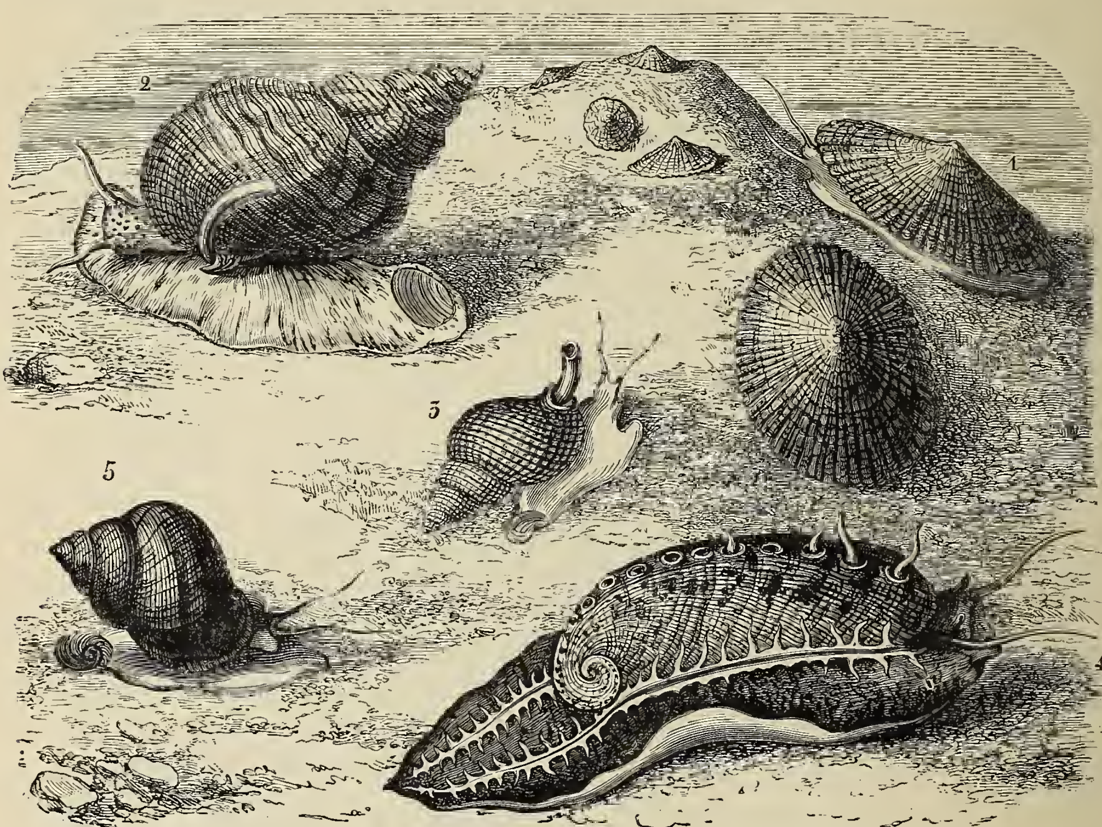
* *Buccina*, a trumpet.

† From *pseudos*, falsehood; and *oliva*, from its resemblance in form to *Oliva*.

‡ From *halios*, of or belonging to the sea.

it is like a land-shell of the genus *Achatina*, the shell being ventricose, and smooth, the apex regular and obtuse.

Notwithstanding the fact that the fossil species of this rare and interesting shell had been found in true marine deposits in Italy associated with sea-shells, and sometimes coated by a coralline (*Lepralia*), yet Dr. Gray for many years adhered to the opinion that *Halia* was a true Land Snail, and placed it as such in the British Museum shell-collection. At length Mr. R. D. Darbishire, of Manchester, having learnt that the specimens hitherto sold had been certainly obtained at Cadiz, set out for Spain, and, by showing a shell (which he carried with him for the purpose) to the fishermen on



A GROUP OF SEA SNAILS—1, PATELLA VULGATA; 2, BUCCINUM UNDATUM; 3, NASSA RETICULATA; 4, HALIOTIS TUBERCULATA; 5, LITORINA LITOREA.

the coast, was rewarded by obtaining several living specimens from deep water off the lighthouse, Cadiz, thus proving the correctness of the evidence derived from the fossil shells from Italy.

The genus *Eburna* (*ebur*, ivory), or "the Ivory-shell," is a thick, solid, smooth shell, with a short spire, umbilicated when young, but the umbilicus is covered by the callus of the inner lip in the adult. These shells have usually lost their epidermis, and are then pure white, spotted with dark-red; the animal's body is also spotted like the shell. Nine species are known from the Red Sea, India, and China. It extends also to Australia and the Cape.

The "Dog Whelk" (*Nassa**) has a shell like *Buccinum*, but is much smaller; the columellar lip is thickened by a callus, and expanded, so as to form a tooth-like projection near the anterior canal. The animal has a broad foot with diverging horns in front, and two little tails behind. *Nassa reticulata* is common on the English shores at low water, and is called the "Dog Whelk" by fisher-

* *Nassa*, a basket used for catching fish.

men. Two hundred and ten species are known, extending from low water to fifty fathoms. They are world-wide in their distribution.

In *Purpura*, the shell is striated, or tuberculated, with a short spire and a large aperture, slightly notched in front, the inner lip being flattened.

Behind the head of *Purpura lapillus*, the only species our island possesses, is a receptacle containing a white fluid, which, on exposure to the air and light, reaches a brilliant tint through several intervening gradations of yellow, green, and blue.* The dye so obtained is made permanent without difficulty; but, although it was formerly used in Irish manufactures, it has long since ceased to be so employed, perhaps through not being procurable in sufficient quantity to make it worth collecting. The egg-bags of the *Purpura lapillus*, commonly called the "Dog Periwinkle," are deposited on the surface of rocks, or stones, or shells, united in considerable numbers to a common membrane, on which they stand erect like so many oval cups, each cup containing an embryo. Here the young *Purpuræ* remain for some months before the cup opens, and when this happens they do not all take immediate advantage of the new-born privilege, but some of them prefer remaining where they are for a time, in ease and comfort, till they acquire sufficient strength and courage to leave the protection of their cells.

PURPURA LAPILLUS.

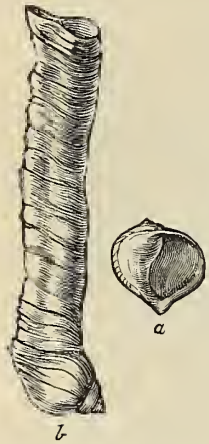
Purpura, like *Litorina*, crawls about on the shore between watermarks, and seldom ventures under the lower tide-mark. It is very destructive to the mussel-beds. Gliding stealthily among the sea-weed and stones, it seeks its prey, and woe to the small Winkle, Limpet, or Trochus that comes within reach of its terrible proboscis. It will bring the aperture of its own shell opposite to that of its victim, and then, introducing its trunk, never leaves it until all the soft parts are transferred to its own capacious stomach. But even where no aperture or door leaves the smaller molluscs open to the attack of his enemy in that way, he is by no means deterred by this little difficulty, for if the object of his attack be a Limpet firmly attached to a stone, or a bivalve tenaciously holding its shell closed, he will manage to perforate the shell, and, through the hole, to draw forth the quivering substance. Mr. Spence Bate relates, that by way of experiment, he placed a *Purpura* in a vessel of sea-water in company with a Mussel, and observed the result. In a short time the *Purpura*, finding that the Mussel was not at all open to his advances, and that the valves of the shell were so firmly drawn together as to leave no chance of effecting an entry between their edges, began to think of attacking him from without. Seeking a portion of the outer surface free from epidermis, he commenced boring. His human observer, repudiating the policy of "non-interference," removed him, and turned the Mussel over, placing that valve uppermost which was most covered with the horny protection. The creature soon managed to turn over the huge body and shell of the Mussel, and resumed his operations at the point where he left off when disturbed, and he did this repeatedly after similar interruptions. At last, quite satisfied that the breach would in time be effected in this way, Mr. Bate resolved to wait no longer for the process, but at once to give the voracious sea snail an opportunity of satisfying its appetite at a smaller demand of exertion from itself and of patience from its observer. To this end he cut the muscles of the bivalve, so as to deprive it of the power of keeping its valves closed. Its fate was thus accelerated; it was now at the mercy of its enemy. The latter no sooner perceived the valves open than, leaving his former work of boring, he seized his advantage by inserting his trunk between the valves, not in this instance realising to the full the general rule, that the enjoyment of an acquisition is increased in proportion to the difficulty and trouble of obtaining it. When not so unexpectedly assisted, however, the hungry *Purpura* exhibits much patience, occupying himself for a couple of days in making his way through a mussel-shell. After gorging himself with a large portion of its contents, he lies for weeks without attempting to procure a fresh supply.

PURPURA PATULA.

* The animal can always be induced to discharge its dye by pressing on the operculum.

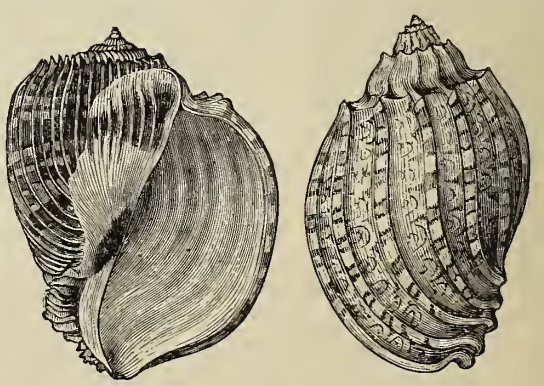
Upwards of one hundred and forty species of *Purpura* are known and described; they are almost world-wide in their distribution, and extend from low water to twenty-five fathoms.

The "Unicorn-shell," *Monoceros*, is peculiar to the West coast of America, whence eighteen species have been brought. The shell is like that of *Purpura*, but with a spiral groove on the whorls, ending in a prominent spine, or tooth, at the lower or anterior end of the outer lip.



MAGILUS ANTIQUUS—A, YOUNG; B, ADULT.

Magilus is a truly remarkable Molluscan genus, living parasitic, and boring in live Coral in the Red Sea, and on the coasts of Mauritius and Java. When young, the shell of *Magilus*, like any ordinary sea snail, is spiral and thin, with its aperture channelled in front; as it grows older, the shell ceases its spiral growth, and is prolonged instead into an elongated, irregular tube, at the extremity of which the animal resides, having in its onward growth filled up its original spiral shell and the greater part of the tube with solid shell-matter, compact and somewhat translucent, like aragonite. Formerly it was believed that the *Magilus*, which lives fixed in the living Coral, grew upward with the growth of the zoophytes in which it becomes immersed; but from specimens obtained, imbedded in the Coral itself, Mr. Charlesworth has shown that *Magilus* grows horizontally, eating its way through the Coral near the living surface, so as probably to reach and devour the zoophytes within, and yet always to remain concealed until the mass of the Coral is cut open, exposing the tortuous and solid, but once tubular shell. It is interesting to notice that in every case in which any animal, say a Crustacean or a Mollusc, becomes parasitic, it invariably loses some of its organs by disuse, and becomes malformed. Witness the "Hermit-crabs" living in sea snails' shells; the *Teredo* in timber; the *Siliquaria* in Sponges; and the *Magilus* in Coral, and many others. When we consider that the coral-boring *Magilus* advances through the *Meandrina*, or other compact Coral, not by the movement of its shell, but by the slow, onward growth of the animal itself, eating its way through the living Coral mass, we can the more readily understand whence it obtains such a store of lime, sufficient to enable it to fill up the deserted earlier portion of its shell with so compact and solid a mass of crystalline material. In the British Museum is a Coral in which a *Magilus* has resided for a long time, and traversed the mass in a tortuous manner, leaving its solid tube behind. In one place, a *Lithodomus*, a bivalve Mollusc, also in the habit of making burrows into the same Coral, has driven its shaft at right angles to the tube of the *Magilus*, and has cut its tunnel right through the solid portion of the shell of the *Magilus*, regardless of its greater density. The tube of *Magilus* is sometimes as much as fifteen inches in length, and very heavy. The animal has a concentric lamellar operculum, with its nucleus near the outer edge. Only one species has been described, the *Magilus antiquus*.

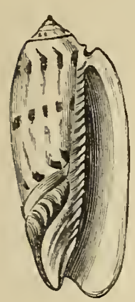

HARPA IMPERIALIS. HARPA ARTICULARIS.

The "Harp-shells" (*Harpa*), so called from the numerous sharp, smooth ribs placed at regular intervals on the surface of the shell, like the strings on a harp, form a group of elegantly-marked and coloured shells. The shell is ventricose, the spire is small, the body-whorl and aperture of shell large, and notched in front. The animal has a very large foot, with the front crescent-shaped, and divided from the posterior part by deep lateral fissures, which are said to separate spontaneously when the animal is irritated. It has no operculum. Nine species are described, all of which are tropical. *Harpa* lives in deep water, on soft, sandy, or muddy bottoms.

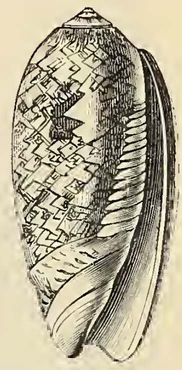
The "Olives" (*Oliva*) are a numerous family, all with cylindrical, highly-polished, often very prettily marked and coloured shells. The spire is very short, the suture is channelled; the aperture is long, narrow, notched in front; the columella is thickened and obliquely striated; and the body-whorl

is furrowed near the base. All these highly-enamelled Gasteropods owe their beautiful polished surfaces to the fact that the mantle-lobes are so large as to meet over the back of the shell, and so effectually protect it from all erosive action. The animal has a very large foot, in which the shell is half buried. The eyes are placed near the tips of the tentacles.

The Olives range from low water to twenty-five fathoms. All the species are very active; they may be seen gliding about near low water, or burying themselves in the sands as the tide retires. They are animal feeders, and attach themselves to the baits on fishing-lines at the bottom.



OLIVA ERYTHROSTOMA.



OLIVA PORPHYRIA.

The Olives are all sub-tropical. One hundred and seventeen species have been described.

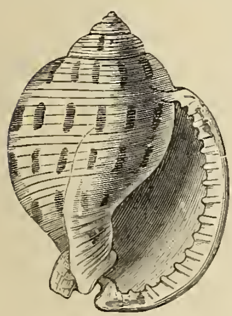
The genus *Ancillaria* resembles *Oliva*, both in its animal and its shell. It is said by d'Orbigny to use its mantle lobes for swimming. The shell has a larger spire than in *Oliva*, and the shell and spire are entirely covered with shining enamel.

In *Ancillaria glabrata* there is formed a sort of umbilicus between the thickened inner lip and the body-whorl. The *Ancillarias* are all sub-tropical shells. Twenty-three species are living.

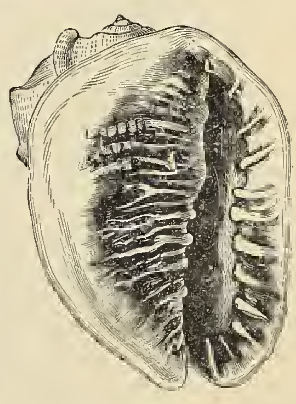
FAMILY IV.—CASSIDIDÆ.

The shells of this family are very much inflated (ventricose) and somewhat globose; the whorls are often ornamented with *varices*, or ridges; the aperture shows a re-curved canal in front; the outer lip is thickened in most; and the inner lip is wrinkled or granular. The "Helmet shells" comprise many of the largest known Gasteropods. They principally inhabit the warmer regions of the globe.

Cassis has a thick tumid shell, with a very short spire, a long aperture, the outer lip bent back and toothed, the inner lip being spread over the body-whorl; the canal is reflected in front. It has a small elongated operculum.



CASSIS CANALICULATUS.



OF CASSIS MADAGASCARIENSIS.

Many of the shells of this species, as *Cassis rufa* and the "Queen-Couch" (*Cassis madagascariensis*), are employed in the manufacture of shell-cameos. The best shell for cameo-engraving is the *Cassis rufa*, from West Africa. The secret of cameo-cutting consists simply in knowing that the inner stratum of porcellanous shells is differently coloured from the exterior. Cameos, in the British Museum, carved on the shell of *Cassis cornuta*, are white on an orange ground; on *Cassis tuberosa* and *madagascariensis*, white upon dark claret colour; on *Cassis rufa*, pale salmon colour on orange; and on *Strombus gigas*, yellow on pink.

Cassis inhabits shallow water. Thirty-four species are living in the tropical seas of to-day. A shell of the genus *Cassis* has been found in the Pre-historic Cave-habitation of Les Eyzies, in Dordogne.*

Dolium, or the "Tun," as this shell is sometimes called, has a large thin, light ventricose shell with transverse ribs or furrows; the spire is short, the aperture very large; the canal is short and reflected; the outer lip is crenated; it has no operculum. Fifteen species are met with in the Mediterranean, India, China, the West Indies, Brazil, New Guinea, and the Pacific.

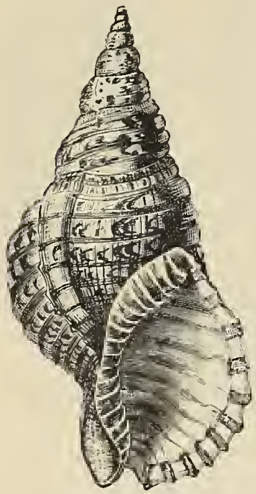
The genus *Cassidaria* is found living in the Mediterranean. The shell is ventricose and tuberculated; the aperture is narrow, ending in a produced and re-curved anterior canal; the inner lip is plicated, and spreads widely over the body-whorl; the outer lip is reflected and crenated.

In *Triton*—the shell usually painted in all mythological pictures as being blown as a horn by sea-deities attendant upon Neptune and Amphitrite—the "periodic mouths," or rests, form alternating

* See "Reliquiæ Aquitanicæ," p. 179.

nodes (or disconnected *varices*) up the spire to the slender apex. Both the inner and outer lip of this genus is denticulated or toothed. More than one hundred species have been found living in the temperate and sub-tropical seas, ranging from low-water to fifty fathoms.

The great *Triton* (*T. tritonis*) is the conch-shell blown by the Australian and Polynesian Islanders. The use of turbinated or spiral shells as trumpets or horns, to sound an alarm with, appears to be of most ancient date and cosmopolitan in extent. The practice is followed among the African aborigines, the natives of the Eastern Archipelago, New Zealand and Japan. "The sound of the trumpet or shell" (writes Ellis, in *Polynesian Researches*, vol. i., p. 283), "a species of Murex (*Triton*) used by the priests in the temple, and also by the herald and others on board their fleets, was more horrific than that of the drum. The largest shells were usually selected for this purpose, and were sometimes above a foot in length, and seven or eight inches in diameter at the mouth. In order to facilitate the blowing of this trumpet they made a perforation, about an inch in diameter, near the apex of the shell; into this they inserted a bamboo cane, about three feet in length, which was secured by binding it to the shell with finely-braided cinet. The aperture was rendered air-tight by cementing the outsides of it with a resinous gum from the bread-fruit tree. These shells were blown when any procession marched to the temple, at the inauguration of the king, during the worship at the temple, or when a tabu or restriction was imposed in the name of the gods. We have sometimes heard them blown. The sound is extremely loud, but the most monotonous and dismal that is possible to imagine." Specimens of these shells may be seen in the Shell Gallery, and also in the Ethnographical Room at the British Museum, prepared for use as horns by the South Sea Islanders.



TRITON VARIEGATUM.

The genus *Ranella* is an ovate-oblong compressed shell, having two rows of continuous varices (or periodic mouths), one on each side, from the apex down the spire to the mouth; the canal is short and re-curved, and the outer lip crenated.

The species of *Ranella*, fifty in number, are mostly tropical; the thicker and more rugose forms are found in rocky situations, and on coral reefs; the winged species, with smoother surfaces, are from deep water. The animals are active, and crawl rapidly. (Adams.) They are chiefly from India.

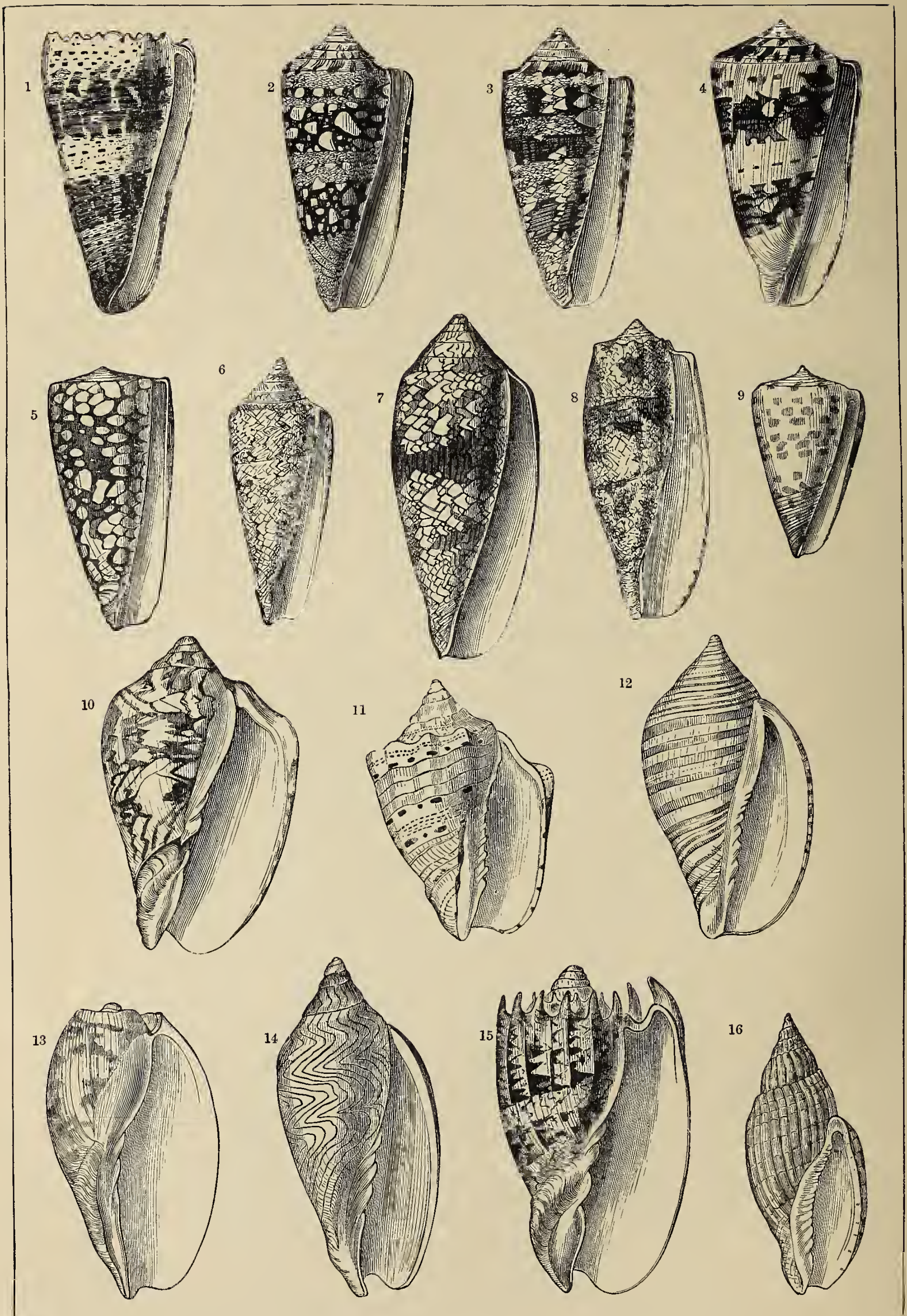
"Sea Snails," says Dr. S. P. Woodward, "certainly take many seasons to attain their maturity, even supposing them to grow twice a year. Dredging operations are usually only carried on in the spring and summer months; yet a large proportion of the mollusca taken are immature. *Eulima* grows a whorl at a time, then thickens its lip and rests; ultimately a straight line is found running down one side of the shell, caused by the coincidence of those 'rests.' In *Ranella* the line of 'rests' is also coincident; but as it only grows half a turn between each there are two rows down the spire."

Pyrula (from the diminutive of *pyrus*, a pear) is the name given to a genus of sub-tropical shells known also as "Fig-shells." It has a fig-shaped or pear-shaped shell, with a short spire; the surface of the shell in many species is ornamented with raised reticulated lines; the outer lip of the shell is thin, and the inner lip smooth; the canal is long and open. It is nearly enveloped in the lobes of the mantle which almost meet on the back of the shell. The animal has a broad truncated foot, but no operculum. The Fig-shell has a wide sub-tropical range. Forty species are described living at from seventeen to thirty-five fathoms depth.

Specimens of *Pyrula perversa* and *Pyrula spirata* have been found in grave-mounds and sepulchral depositories in different parts of Western Canada, illustrating the extent of traffic carried on between the north and south in ages prior to the displacement of the red man by the European.

FAMILY V.—CONIDÆ.

The great family of the Cones is characterised by the remarkably persistent form of their shells, being an inverted cone, with a very long and narrow mouth, and a sharp-edged outer lip. Clothed in



CONES AND VOLUTES.

1, Conus imperialis ; 2, 3, 4, ammiralis ; 5, C. nobilis ; 6, C. gloria-maris ; 7, C. textile ; 8, C. geographus ; 9, C. tesselatus ; 10, Voluta scapha ; 11, V. musica ; 12, V. vexillum ; 13, V. cymbium ; 14, V. undulata ; 15, V. imperialis ; 16, V. Delessertii.

a dull, yellowish-brown epidermis, they offer no peculiar attraction in the living state. But when this natural covering is removed, and the shells have been carefully cleaned by a skilled hand, we are struck by the extreme beauty and diversity of patterns and colours which they display.

"The Cones," says Adams, "are principally inhabitants of the equatorial seas. Haunting the holes and fissures of rocks, and the labyrinths of coral-reefs, they lead a predatory life; boring into the shells of other molluscs and sucking the juices of their bodies."

Nearly three hundred living species have been described.

The genus *Conus* embraces many of the most highly-prized shells which are known to collectors. "Individuals," writes Dr. S. P. Woodward, "of many species are almost as abundant as the Cowries, while a few, and these are amongst the most conspicuous, are exceedingly rare." The *Conus neptuni*, in Mr. Cumming's collection;* *Conus caledonicus*, in that of the Baron Delessert; and *Conus Brownii*, in the cabinet of M. Bowin, are considered unique. A specimen of *Conus thalassiarchus* was sold for £4 15s.; and good specimens of *Conus nobilis* are worth from £3 to £6. The "Admiral" (*Conus ammiralis*) is a beautiful shell, although no longer esteemed a great rarity; but *Conus cedo-nulli* has maintained its fame for a century, on account of the variety of painting it exhibits, and the extreme rarity of fine examples. A specimen was sold at Mr. Harford's sale for £16. The rarest of all Cones, and perhaps of all shells, except the living *Pleurotomaria*, is the *Conus gloria-maris*, which those old pagan Dutchmen worshipped, as did the Greeks the Paphian Venus. Perhaps it was this cone of which a Frenchman is related to have had the only specimen, except one belonging to Hwass, the great Dutch collector, and when this came to the hammer he outbid every rival, and then crushed it beneath his heel, exclaiming, "Now, my specimen *is* the only one." Doubtless many traditions respecting the *Conus gloria-maris* yet linger in the marts of Amsterdam; with us it is still worth ten times its weight in gold. The Museum specimen formed part of the collection of the late Mr. W. J. Broderip, who gave £70 for it; and a second, in the cabinet of Mrs. De Burgh, was originally obtained from Holland for the late Mr. Norris, of Bury, a veteran collector, who expressed himself highly privileged to become the possessor in his old age of such an unexpected treasure.† The Cones range northward as far as the Mediterranean, and southward to the Cape; but they are most abundant and varied in the equatorial seas. They are found in shallow water down to forty or fifty fathoms. The animal moves slowly, and some species (as *Conus aulicus*) bite when handled. (Adams.)

TEREBRA TIGRINA.

The shells of the genus *Pleurotoma* ‡ are turreted, fusiform, with an elevated spire, an oval aperture, and a long and straight canal; the columella is smooth, the outer lip being notched in front and having a deep slit near the suture. The eyes are at the outer bases of the tentacles, which are wide apart. The mantle has a slit in the hinder part on the right side; the siphon is straight. The operculum is pointed, with an apical nucleus. This is a most prolific genus, numbering about five hundred species, and distributed from Greenland to the Cape; they are, however, most numerous in Asiatic waters, and are met with from low water-mark to one hundred fathoms.

The *Terebra*, or "Augur-shell," as it is called, from its long, pointed, many-whorled shell, like a borer, has a short canal, a small mouth, and a pointed operculum. The siphon is long and re-curved. The animal, in some species, is blind, and in others has the eyes at the extremity of minute tentacles. All the shells of this genus are smooth, and ornamented with variegated spots, generally red, brown, and orange colour. They are widely distributed over the world. One hundred and ten species are described, most of which are tropical.

FAMILY VI.—VOLUTIDÆ.

The shell in this family is notched in front for the siphon, the columella is regularly and deeply plaited, and the operculum is absent. The animal has a very large foot, partly covering the shell, the siphon is re-curved, and the eyes are placed at the base of the tentacles.

* Now in the British Museum. † "Recreative Science," 1860.

‡ *Pleura*, the side; *tome*, a notch.

"The 'Volutes' have large and fine shells, elegant in their form, and often remarkable for their painting and rich colour. They are tropical shells, numbering about one hundred species, and have been grouped in about half a dozen sections or sub-genera, examples of some of which are difficult to obtain. The *Voluta abyssicola*, supposed to be the living representative of the fossil Volutes of the London Clay, is now only known by a unique specimen from deep water off the Cape, formerly in the collection of Mr. Lombe Taylor. The *Voluta aulica* was unique until Mr. Cumming's return, and Sowerby valued the Tankerville specimen at forty guineas. *Voluta fulgetrum*, in the same collection, was priced at £31, and *Voluta papillosa* £21. The fine *Voluta junonia* in the British Museum is worth £40; and the less conspicuous *Voluta piperata*, acquired at M. Vernède's sale, was valued at £16. The *Voluta reticulata* in Mr. Norris's collection cost £30; and Mr. Dennison gave £20 for the first specimen of *Oniscia Dennisoni*, and his collection is remarkable for the number of fine and costly shells it contains." (S. P. Woodward.)

The Volutes extend from the littoral zone to one hundred fathoms depth. *Voluta junonia* was dredged in the Gulf of Mexico, at a depth of seventy fathoms.

The genus *Melo*, or the "Melon," has a large, somewhat oval, inflated shell, with a short spire, the apex of which is obtuse and rounded (mammillated), and the whorls are smooth. The columella has several oblique plaits on it, the outer lip is thin and simple, and the shell is truncated in front. Most of the species of *Melo* are ornamented with a variety of colours, and the whorls are adorned with a diadem of spines; the living shell is covered with a greenish-brown epidermis. The foot is large and thick; the eyes are at the outer bases of the tentacles. The animals of *Melo* and *Cymba* are both ovo-viviparous, bringing forth their young alive without egg-shells. The natives of the Papuan Islands use the shell of the *Melo* to bail out their canoes with. About ten species of *Melo* are described, principally from New Guinea.

The genus *Cymba*, or the "Boat-shell," is less elegant than the "Melon;" the embryo or apex of the shell is large and globular; the whorls few, and flattened. The writer has captured large numbers of the living *Cymba olla* in Catalan Bay, at the east side of the rock of Gibraltar, in the Mediterranean, cast ashore after a heavy sea from the south-east. They were trying to bury themselves by the aid of their huge foot in the sands, but the sun dried the sand faster than they could dig down, and so they fell a prey to the collector! Like *Melo*, it is ovo-viviparous, and the young, when born, are an inch in length. Ten species are described from the West Coast of Africa, the Straits of Gibraltar, and as far north as Lisbon.

Marginella is a smooth, bright shell, with a short or truncated spire, a narrow aperture, a plaited inner lip, and a thickened outer lip. The animal is like Cypræa. There are ninety species of these pretty little shells described, mostly tropical. Numerous beads have been found, made of the shells of the genus *Marginella*, in ancient graves discovered in Tennessee. The shells were ground down so as to make a perforation on the back, by means of which they could be strung together for purposes of personal ornament.

FAMILY VII.—CYPRÆIDÆ.

In this family the head of the animal is broad, the rostrum short, the tentacles long, the eyes placed on projections near their external bases, the siphon is long, the mantle has large expanded side-lobes covering the shell. There is a single branchial plume; the operculum is wanting.

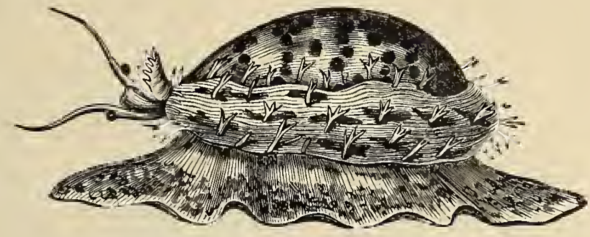
The shell (as in all Molluscs where covered by the mantle-lobes) is usually smooth and polished; and the last whorl is large, convolute, and wholly or partially conceals the others; the outer lip is bent inwards, thickened, and toothed, the inner lip is dentated or corrugated. The mantle-lobes are often ornamented along their borders with filaments or serrated edges; sometimes, however, they are smooth and simple. The foot is large, expanded, and often greatly elongated behind.

"In their habits the Cowries are shy, and crawl slowly; they are nearly all tropical animals, inhabiting the warmer seas; and as they glide along among the coral reefs and in the shelter of rocks, with the lateral lobes of their mantles adorned with showy colours, they present to the eye of the naturalist objects of singular interest and beauty." (Adams.)

There are few shells that are more persistent in form than are the "Cowries." In *Cypræa* proper the shell is somewhat cylindrical in form when adult, varying, however, according to the

age of the animal: in the very young it is thin, pellucid, and like a snail-shell, it afterwards becomes like an *Oliva;* finally, the outer lip is bent in and the inner lip is dentated; and we have the adult Cowry, in which we fail to detect the apex at all.

How much of the wonderful natural history of such common objects as the "shells from the sea-shore" is lost to the great majority of mankind; and yet what marvels are revealed to the eyes of the trained observer of nature! The beauteous shell of the Cowry lies concealed within the folds of its mantle; that of the Cone is covered by a thick rough epidermis, which has to be removed before its hidden beauties are discovered.



THE COWRY (CYPRŒA TIGRIS) AND ITS ANIMAL.
The Shell is here drawn exposed to view; it is usually entirely covered by the lobes of the mantle.

"God's works," writes Professor Forbes, "are never left unfinished. None is too minute for the display of infinite perfection. The microscope has exhibited to our wondering eyes beauties of structure that have been concealed from mortal sight for long ages. It would almost seem as if only glimpses of those excellences of creation are permitted to man to behold, whilst the full contemplation of such wondrous charms is reserved for immortal and invisible admirers."

But living Molluscs not only secrete shell-matter: they have likewise the power to absorb the internal convolutions and *columella* of their shells, either completely or until it is reduced to the thinnest film. The Cone removes all but a paper-like portion of its inner whorls, and the *Cypræa* often goes still further in removing all trace of its axis.

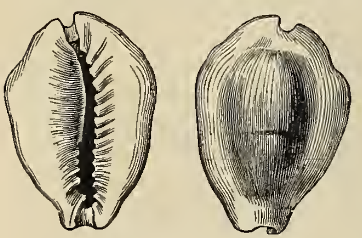
The Cowry owes the glassy polish of its whole exterior to the amplitude of its mantle, whose folds meet over its back, and ordinarily conceal the shell entirely. In the shining Marginellas, and Olives, and some Volutes, the shell is partially glazed by the same envelope. It is absolutely essential that the mantle should cover any part of the shell to which additions are required; any injury, therefore, beyond the reach of this mantle externally must be repaired from the interior. This will explain why the broken apices of univalves and the eroded umboes of the river Mussel are never repaired externally, but always by deposits within the spire or the valves of the shell.

The size of the adult shell is often characteristic of the species, but this is by no means uniform. The author has frequently seen specimens of *Cypræa turdus* equally adult, measuring three-quarters to one inch and a half, but the dwarf varieties are more common than the giants.

Since the year 1825, when George Sowerby catalogued and priced the Tankerville collection, shells have much diminished in pecuniary value, and shillings will now generally go as far as guineas did then. This depreciation has chiefly affected the deep-sea shells, which have become more plentiful since the employment of the dredge has been generally introduced, and land shells, which are mostly procured in abundance when their proper localities are understood. But some shells seem destined to be always scarce, like the Orange Cowry and the *Conus gloria-maris.* No doubt there are "as good fish in the sea as ever came to net," but sometimes they live in inaccessible places. Shell-collectors, like the old Dutch florists, have always set apart a few genera as the special objects of their affection, to which they attach a fanciful value. These are the Cones, Cowries, Mitres, and Volutes, with a few miscellaneous species belonging to other genera, such as the Thorny Oyster, Wentletrap, Carinaria, Harp, and Rostellaria. Most of the stories told about the extravagant prices paid for particular shells are probably apocryphal or grossly exaggerated. It is said that a Parisian "professor of botany" paid 6,000 francs (£240) for a Thorny Oyster (*Spondylus regius*), and that a Dutchman gave *an estate* for a Wentletrap (*Scalaria pretiosa*). Now the *Scalaria* is worth from 5s. to 10s., and the finest *Spondylus* in England was purchased by Mrs. de Burgh for £5. The *Carinaria vitrea*, which, according to Sowerby, once realised one hundred guineas, is still worth £12 in the market, and fetched as much as £15 only a few years ago; but the value of fine specimens of this shell is enhanced by its extreme fragility. One of the Orange Cowries in the British Museum was purchased by Mr. Broderip of the late Mrs. Mawe for £30, although it has holes in it made by the natives; and fine

specimens are still worth ten guineas. The *Cypræa leucodon*, in the same collection, is unique, and worth £50; the *C. princeps* was valued at £60; and other examples have realised £40 at the Tankerville sale, and £40 at the sale of Mr. Holford's collection; Mr. Dennison, of Liverpool, had one which cost £35. The specimen of *Cypræa guttata* in the British Museum is valued at £40; and the rare little *Cypræa Barclayi*, when first brought to England, obtained £10; and *Cypræa guttata* has realised sums varying from £12 to £30, within the last ten years, and as the specimens are generally in poor condition, it is certain that fine examples would still command a high price. The cabinet of Miss Saul, of Bow Lodge, is considered to be richer than any other in this group of shells, and the late Mr. Gaskoin, who wrote a monograph of the genus *Cypræa* had a very extensive series, which afterwards was united to the magnificent collection of the late Mr. Lombe-Taylor, of Starston. (S. P. Woodward.)

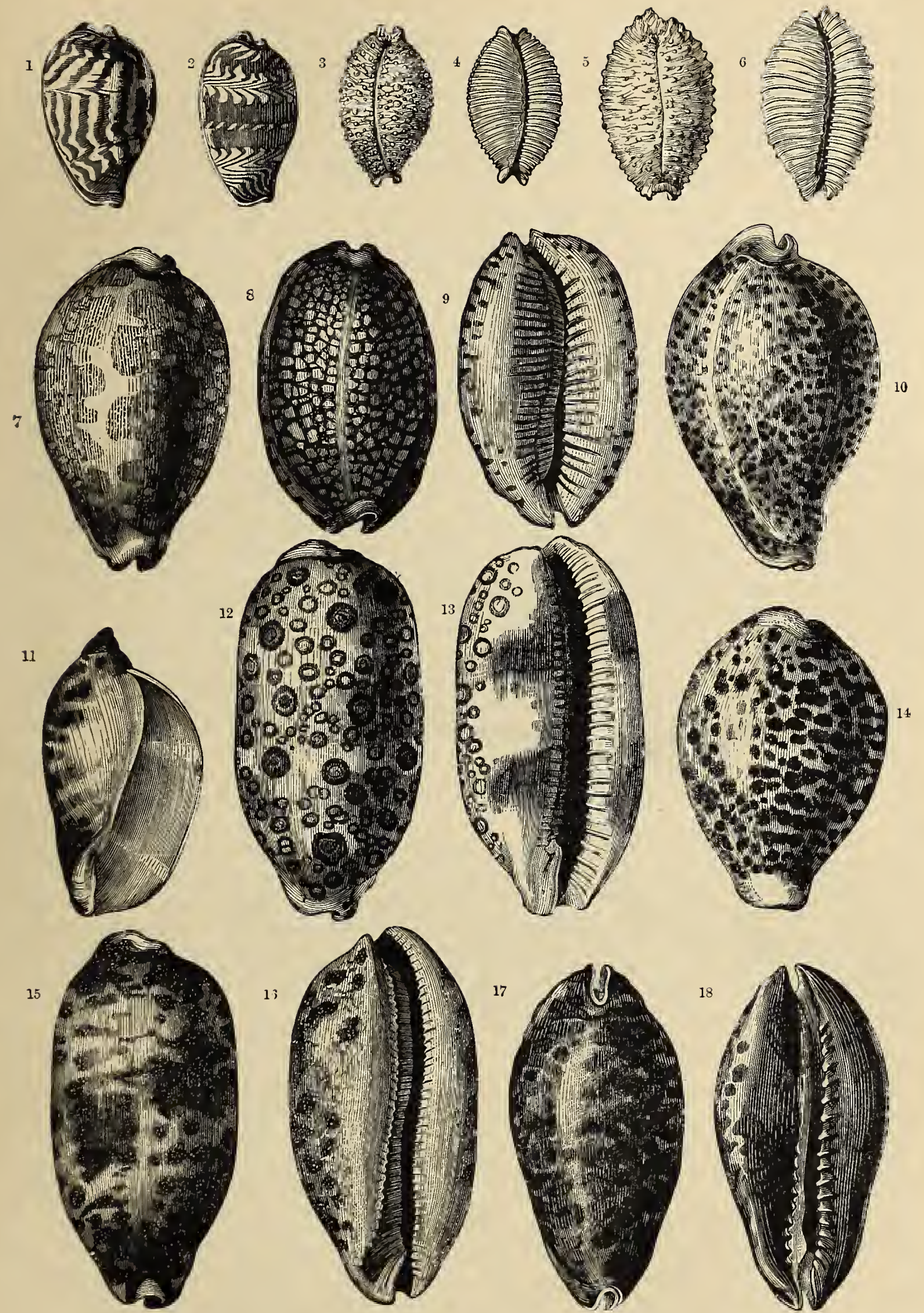
The Money Cowry (*Cypræa moneta*) is a native of the Pacific and Eastern seas. Many tons weight of this little shell are annually imported into this country, and again exported for barter with the native tribes of Western Africa. In the year 1848 sixty tons of the Money Cowry were imported into Liverpool. Wilson says of *Cypræa moneta*:—"The Cowry shells used as currency are procured on the coast of Congo, and in the Philippine and Maldive Islands. Of the latter, indeed, they still constitute the chief article of export. At what remote date, or at what early stage of rudimentary civilisation, this singular representative shell-currency was introduced, it is perhaps vain to inquire, but the extensive area over which it has long been recognised proves its great antiquity. The Philippine Islands form, in part, the eastern boundary of the Southern Pacific, and the Maldives lie off the Malabar Coast, in the Indian Ocean; but their shells circulate as currency not only through Southern Asia, but far into the African continent."


THE MONEY COWRY.

In Ellis's "Polynesian Researches," vol. ii., p. 292, he gives an account of fishing for Cuttle-fish with an artificial bait, formed of a piece of hard wood, to which a number of the most beautiful pieces of the Cowry, or Tiger-shell, are fastened one over another, until it is about the size of a turkey's egg, and resembles the Cowries. It is suspended in a horizontal position by a strong line, and lowered by the fishermen from a small canoe until it nearly reaches the bottom. The fisherman continues gently to jerk the line, when the Cuttle-fish, attracted by the appearance of the Cowry, darts out one of its arms, which it winds around the shell, and fastens among the openings of the plates. The jerking being continued, the fish puts out another and another arm, till it has quite fastened itself to the shell bait, when it is drawn up into the canoe and secured.

One of the earliest uses to which the shells of Mollusca appear to have been applied was that of articles of dress. In MM. Lartet and Christy's "Reliquiæ Aquitanicæ" (Part III., 1866, B., Pl. v., Figs. 15–20) we find illustrations of several shells—viz., *Cypræa pyrum*, *Pectunculus glycimeris*, *Arca Breislaki*—which show clearly, by their having been perforated, that they had been worn either as ornaments or charms by the aborigines who inhabited the cave of La Madelaine. The custom of using shells, &c., as necklaces or other personal decorations, is common, not only amongst savages, but even amongst civilised races at the present day. In this case the shells have been obtained, not from river or sea, but from the Faluns of Touraine or Bordeaux, deposits of Miocene age, rich in fossil marine shells, many of which are so well preserved as to retain the glazed surface seen in recent specimens. Dr. Fischer, of Paris, has determined as many as five species in the caverns of Perigord.

An Oolitic Belemnite, having its sides squared by grinding, was found among the *débris* in the cavern of Bruniquel, department Tarne et Garonne; also an Ammonite and a Gryphæa, probably introduced by children as toys. Perforated recent marine shells were likewise numerous. These relics are preserved in the British Museum. Shells are at the present day as greatly in demand for ornamental purposes as in pre-historic times. The Chinooks of Oregon ornament their noses and ears with shells of *Dentalium*. The Friendly and Fiji Islanders wear the Orange Cowry (*Cypræa aurora*) as a mark of chieftainship. The natives of Flinders Island and the New Zealander polish the *Elenchus* into an ornament more brilliant than the "pearl ear-drop" of classical or modern times.



COWRIES.

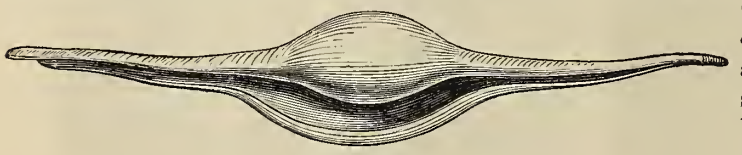
1, 2, Cypræa undata ; 3, 4, C. nucleus ; 5, 6, C. madagascariensis ; 7, C. mappa ; 8, 9, C. histrio ; 10, C. pantherina ; 11, C. Scottii (young) ; 12, 13, C. argus : 14, C. tigris ; 15, 16, C. testudinaria ; 17, 18, C. Scottii (adult).

Cypræa shells are worn as a head-dress by the natives of New Guinea. The time would fail in which to tell all the various methods used in applying shells as ornaments to the head, dress, and person. Every book of travels in Africa, America, or the South Sea Islands teems with such illustrations. Nor does India furnish an exception to the rule; for there the female children have their arms and ankles, from infancy, encircled with broad shell-bands, cut from the whorls of the great *Turbinella pyrum*, and our Sepoy troops wear necklaces, made from the canal of the same shell, as part of their parade uniform.

One hundred and fifty species of living *Cypræa* have been described. They occur in all the warmer seas of the globe, but are most abundant in the Old World.

The genus *Trivia* is peculiarly interesting to us, as it includes the only Cowry found upon our British coast—the *Trivia Europæa*. The shells of this genus are sometimes covered with transverse raised ribs across the back, as in *Trivia Europæa* and *T. pediculus;* and sometimes with elevated tubercles, as in *T. pustulosa;* or with both, as in *T. staphylæa*. Thirty-five species are recorded; they are all small forms. Near the edge, at low water, you may sometimes see our little British *Cypræa* crawling on the sandy bottom. The animal is not more than half an inch long, of a bright orange colour, duskily banded, or yellow with orange edge, or all of a pale pink colour. In front are two slender tentacles, with small black eyes near their bases; between these horns is a small tube bent upwards—this is the siphon. The shell is wrapped up in the two lobes of the gaily-coloured mantle; the foot is square in front and very long and pointed behind. At the slightest touch the foot and mantle-lobes, feelers, and siphon all disappear, and the little flesh-coloured ribbed shell alone remains, all the soft parts being contracted within the narrow-toothed mouth of the shell, leading us to wonder how so tiny a shell is able to accommodate so large an animal.

The pretty little shells belonging to the genus *Erato* differ from *Marginella*, with which they have been confounded, in not having a marginal varix, or swelling, and from *Cypræa* in having distinct plaits on the columella; the outer lip, too, is thickened towards the middle and denticulated within. One species (*Erato lævis*) is found on our North British coast, and also in the Mediterranean. Eleven species are described from the West Indies and China.



OVULUM VOLVA.

The shells of the genus *Ovulum* (the "China shell") are never ornamented with rich and varied colours, like those of the Cowry tribe, but are usually white, pink, pale violet, or yellow, without exhibiting any particular markings or pattern. The shell is like *Cypræa*, but the inner lip is smooth. *Ovulum volva* ("the Weaver's Shuttle") has the aperture of the shell drawn out into a long canal at each end. The foot is narrow, and adapted for clasping the round stems of the *Gorgoniæ*, on which the animal feeds. Thirty-four species are described, inhabiting the warmer seas of the West Indies, Mediterranean, China, and West America. Two species (*O. patula* and *O. acuminata*) are met with on our own shores.

CHAPTER III.

THE GASTEROPODA (*concluded*) AND PTEROPODA.

Order I. (*concluded*)—(*b*) the Holostomata, or Entire-mouthed Sea Snails—Family 8. NATICIDÆ—9. CANCELLARIADÆ—10. PYRAMIDELLIDÆ—11. SOLARIADÆ—"The Staircase-Shell"—12. SCALARIADÆ—Scalaria pretiosa, the "Wentletrap"—Great Value attached to this Shell—13. CERITHIADÆ—Potamides in Fresh Water—14. TURRITELLIDÆ—"Tower-shells"—Vermetus—Worm-shells—15. MELANIADÆ—16. PALUDINIDÆ—Fresh-water Snails—the "Apple Snail," Ampullaria—Its Tenacity of Life—17. LITORINIDÆ—Periwinkles as Food—18. CALYPTRÆIDÆ—"Bonnet Limpets"—The Grotto-shells, Phorus—19. TURBINIDÆ—Trochus—20. HALIOTIDÆ—The Ear-shell, Haliotis—Uses of Pearly Shells—Pleurotomaria—Its Rarity—21. IANTHINIDÆ—Ianthina, "Floating Shells"—The Raft—22. FISSURELLIDÆ—23. NERITIDÆ—24. PATELLIDÆ—"Limpets"—Used as Food—How the Oyster-catcher Detaches them—25. DENTALIADÆ—26. CHITONIDÆ—Multivalve Snails—Order II., PULMONIFERA—Air-breathers—Anatomy of a Snail—Inoperculata, or Land Snails without Operculum—Characters—Curious Experience of a Desert Snail—27. HELICIDÆ—Used as Food—The Largest Land Shell Known—The Odontophore, or Tooth-bearing Tongue—Other Genera—28. LIMACIDÆ—The Slugs—The Mucus Secretion and its Uses—29. ONCIDIADÆ—30. LIMNÆIDÆ—Air-breathing Pond Snails—31. AURICULIDÆ—Operculata, or Operculated Land Snails—32. CYCLOSTOMIDÆ—33. HELICINIDÆ—34. ACICULIDÆ—Order III., OPHISTHOBRANCHIATA—35. TORNATELLIDÆ—36. BULLIDÆ—37. APLYSIADÆ—"Sea Hares"—38. PLEUROBRANCHIDÆ—39. PHYLLIDIDÆ—The "Sea Slugs"—40. DORIDÆ—41. TRITONIADÆ—42. ÆOLIDÆ—43. PHYLLIRHOIDÆ—44. ELYSIADÆ—Order IV., NUCLEOBRANCHIATA—Oceanic Snails—45. FIROLIDÆ—The Carinaria—46. ATLANTIDÆ—Class III., PTEROPODA—Their Pelagic Character—Their Abundance—Source of Food to the Right Whale—Their Wing-feet compared to Moths—Delicacy of their Shells—Distribution.

Division b.—HOLOSTOMATA.*—In the section already described, the SIPHONOSTOMATA are marked (as we have seen) by the respiratory siphon protruding from the anterior canal of the shell, indicating their carnivorous propensities. In this section, the HOLOSTOMATA, the respiratory siphon is not (as a rule) so produced, and the mouth of the shell is therefore entire, and not drawn out into a canal in front. The animal has usually a short, non-retractile muzzle; the gills are comb-like or plume-like. Most of this division are vegetable-feeders and dwellers in marine or fresh water.

FAMILY VIII.—NATICIDÆ.

In this family the shell is globular, with few whorls; its spire is small and obtuse; the aperture is semi-lunar, with an acute lip; the pillar of the shell is often thickened by a callus. The animal has a long, retractile proboscis; the lingual ribbon is linear; the foot is very large, the mantle-lobes enveloping the greater part of the shell. All the species of this family are marine.

In the genus *Natica* the shell is smooth and thick and the inner lip callous; the umbilicus is large, having a spiral callus. The operculum is sub-spiral and shelly. The animal is blind; the foot is large, having a fold in front protecting the head; the lobes of the foot cover part of the shell. The animal is carnivorous, feeding on the smaller bivalves. (Gould.) They are themselves devoured by the Cod and Haddock and the larger Star-fishes. The eggs of the Natica are agglutinated into broad and short spiral bands, unattached. The animal frequents sandy and gravelly bottoms, from low water to ninety fathoms. (Forbes.)


NATICA PAPILIONIS.

The colour-markings on the shells of Naticas are very indestructible; they are frequently preserved in fossil shells. The species are numerous; more than ninety have been described distributed from the Arctic Seas, the shores of Britain, and the Mediterranean, to India, China, America, Australia. They occur also in the Caspian.

In the genus *Sigaretus* the shell is ear-shaped, the aperture is very wide and oblique, the surface of the shell is striated, the operculum is minute, horny, and sub-spiral. The shells of the flatter forms are entirely concealed by the mantle of the animal; the convex forms are partially so. The epidermis is yellowish. The foot is enormously developed in front. Twenty-six species are described living in the East and West Indies, China, and Peru.

In the genus *Velutina* the animal has a thin shell and a velvety epidermis; the spire is small, the suture deep, and the aperture very large and rounded; the shell has no operculum. The margin of the mantle is developed all round, and turned up over the shell; gills, two; head broad; tentacles blunt, far apart, eyes at their outer bases. The animal is carnivorous. Four species are described from Britain, Norway, and North America.

* From *holos*, entire; *stoma*, mouth.

FAMILY IX.—CANCELLARIADÆ.

The animals of this family are remarkable for the simple nature of the oral apparatus, both tongue and teeth being wanting; the head, moreover, does not seem to be elongated, the rostrum being rudimentary; the operculum is also wanting. The shell has the aperture more or less channelled in front, and the columella is plicated. (Adams.)

The genus *Cancellaria** includes a large number of moderate-sized shells, the surface of which is cancellated or cross-barred, or reticulated by a double series of parallel lines, one running around the shell-whorls from the mouth to the apex, the others transversely, corresponding to the varices, or periodic mouths, of *Triton* and *Ranella*. There are several strong oblique folds on the columella. The animal has no operculum. Contrary to the other members of this family, the animals in this genus are vegetabe feeders. They are remarkable for the elegance of their shells. Seventy species are described from the West Indies, China, South America, and the Eastern Archipelago, ranging from low water to forty fathoms.

The genus *Trichotropis*, of Broderip, has a turbinate and thin, somewhat elevated, shell, more or less umbilicated, spirally furrowed and cancellated, often furnished with epidermal fringes on the ribs; apex of spine acute, aperture pyriform, outer lip simple acute, inner lip flattened, canal rudimentary. More than twelve species are described, mostly from the Northern seas, from fifteen to one hundred fathoms.

FAMILY X.—PYRAMIDELLIDÆ.

In this family the characters are: tongue unarmed; teeth none, or rudimentary; tentacles broad, folded ear-shaped, eyes at their inner bases; mantle enclosed with a siphonal fold; foot short in front, produced behind; operculum horny, sub-spiral; shell turreted, aperture entire, columella plaited. The species of this group are all marine, and probably predacious and carnivorous, as they have a retractile proboscis.

The species of the genus *Pyramidella* live in sandy bays and on shallow mud-banks, concealing themselves under the surface, and indicating their presence by forming slender raised tracks. Eleven species occur in the West Indies, Mauritius, and Australia.

The genus *Odostomia* includes a number of very minute shells, having the habit of *Rissoæ*, and, like them, sometimes found in brackish water. They range from low water to fifty fathoms. The shell is subulate or ovate, smooth; apex sinistral, aperture ovate, columella with a single tooth-like fold, lip thin, operculum horny. About thirty-five species have been described from British, Mediterranean, and Madeiran coasts.

The genus *Chemnitzia* was named in honour of Chemnitz, a distinguished German conchologist, of Nuremberg, 1780-95, and the author of a great work on conchology.

The shell is slender, many-whorled, the whorls plaited; apex sinistral; aperture simple, ovate; peristome incomplete; operculum horny, sub-spiral. The animal has a long retractile proboscis; eyes at inner bases of the triangular tentacles; foot truncated in front.

The genus *Chemnitzia* is world-wide in distribution. Seventy species are recorded from low water to one hundred fathoms.

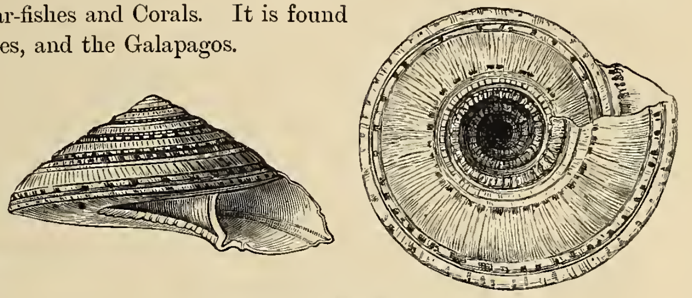
Eulimella has an elongated, solid, many-whorled, smooth, polished shell; the mouth is sub-quadrate; peristome incomplete; columella straight, and smooth. Four species are described: from Britain, Norway, and the Mediterranean.

Monoptygma is the name of a genus of shells of great beauty and delicacy, resembling greatly elongated forms of *Actæon*. The animal is nearly allied to *Aclis* in its short tentacles, with the eyes at their inner bases, rudimentary tongue, and elongated narrow foot. Twelve species are recorded by Adams, from India, China, and elsewhere.

In the genus *Eulima* the shell is elongated, white, smooth, polished; the spire is produced, many-whorled; the apex is acute; aperture oval, pointed behind; the inner lip is reflected over the pillar, the outer lip is thickened internally. The Eulimæ crawl with the foot greatly in advance of the head, which is usually concealed beneath the margin of the shell. Many of them have distorted shells, the upper whorls being often bent or inclined out of the straight line. Twenty-six species are recorded, from Cuba, Norway, Britain, Mediterranean, Australia, India, and other parts, in five to ninety fathoms.

* Latin, *cancellatus*, cross-barred.

Stylina has a glassy, globular shell, with a tapering apex and a sinistral nucleus. The animal has a thick mantle, which is bent over the last whorls of the shell. It lives attached to the spines of Sea Urchins, or buried in living Star-fishes and Corals. It is found in Britain, the West Indies, Philippines, and the Galapagos.



SOLARIUM PERSPECTIVUM.

FAMILY XI.—SOLARIADÆ.

The proboscis in this family is retractile, and the tongue (according to the observations of Dr. Gray) is entirely unarmed; the tentacles are laterally folded, the eyes are on the upper surface at their bases; the mantle is included; foot moderate, and formed for walking; the operculum horny, spiral, oval, or circular. The genus *Solarium*, or the "Staircase Shell"—so named because the spiral edges of the whorls seen in the umbilicus have been fancifully compared to a winding staircase—has a depressed orbicular shell, with a wide and deep umbilicus. The aperture of the shell is squarish, the peristome is thin, the operculum horny and sub-spiral. There are twenty-five species, all from sub-tropical and tropical seas, and very widely distributed.

FAMILY XII.—SCALARIADÆ.

The animals in this family are predacious. The mantle is enclosed with a rudimentary siphonal fold; the foot is obtusely triangular and grooved below; the tentacles are slender, and the eyes are placed at their outer bases; the operculum is horny and spiral. The shells are nearly all white; they are spiral and turreted, and are ornamented with varices; the aperture is circular, without any notch or canal. The shells are remarkable for their extreme elegance of form.

The genus *Scalaria*, known commonly as the "Wentletrap," or "Ladder-shell," has mostly a pure white lustrous shell, the whorls of the turret-like shell being round and nearly separate, merely united by the sharp transverse ribs. When molested, the animal exudes a purple fluid. The species exceed one hundred in number, and range from low water to one hundred fathoms. Most of the species are tropical, but there are exceptional species found on the coasts of Greenland and Norway. The others are almost world-wide. In the "Wentletrap" (*Scalaria pretiosa*) the periodic mouths encircle the shell-whorls, which are sometimes separate, and contribute not a little to the beauty of this once costly conchological treasure.

SCALARIA PRETIOSA.

FAMILY XIII.—CERITHIADÆ.

In this family the shell is spiral and many-whorled, the mouth of the shell is channelled in front, and the outer lip is usually expanded in the adult shell. The animal has a broad and short rostrum, with the tentacles wide apart; the eyes are on short stalks united to the base of the tentacles. The mantle-margin has a rudimentary siphon-fold in front; the foot is broad and short, and angular in front; the operculum horny and spiral. The members of this family are met with in marine, estuarine, and fresh-water localities.

CERITHIUM ALUCO.

The genus *Cerithium*, or the "Horn-shell," has a turreted, many-whorled shell, with indistinct varices; the canal is produced in front, and slightly recurved; the columella is thickened and callous behind. *Cerithia* are found in all parts of the world. More than one hundred living species have been described.

*Potamides** is the name given to a group of fresh-water *Cerithia*, with thick olive-brown epidermis, and an orbicular many-whorled operculum. They are found chiefly in the Old World, especially in Africa and India, inhabiting the mud of large rivers.

The genus *Aporrhais*, or the "Spout-shell," is a shell with an elongated spire, composed of

* From *potamos*, a river; and *eidos*, used in the sense of species.

numerous tuberculated whorls, the aperture narrow, but the outer lip greatly expanded, lobed, and digitated; the operculum is pointed and lamellated. The muzzle of the animal is short and broad; the tentacles are cylindrical; the eyes are on prominences near their outer bases; the foot is short, rounded in front, pointed behind. Three species are described living at twenty to one hundred fathoms, in Labrador, Norway, Britain, the Mediterranean, &c.

*Struthiolaria** is a turreted shell with angular whorls. Its aperture is truncated in front; the columella is very oblique; the outer lip is prominent, thickened; inner lip callous, expanded; operculum claw-shaped. Five species occur in Australia and New Zealand.

TURRITELLA TEREBELLATA.

FAMILY XIV.—TURRITELLIDÆ.

The shell in this family is tubular or spiral, the upper part being partitioned off. The aperture of the shell is simple; the operculum horny, many-whorled. The animal has a short muzzle, eyes on head at the outer bases of the tentacles, mantle fringed, foot short, tongue armed. This is a strictly marine group, the species ranging from low-water-mark to a depth of one hundred fathoms. Their geographical distribution extends over most of the countries of the globe, one species being an inhabitant of the British seas. They are commonly called "Screw-shells," from their peculiar form.

In the genus *Turritella* ("Tower-shells"), the shell is turreted, many-whorled, spirally striated, the aperture round, margin thin. The shells of this genus are spotted and variegated, generally with red and brown. The species inhabit all parts of the world, being most numerous in tropical countries. The writer has taken the *Turritella communis* by the dredge-full off the Bay of Malaga (Mediterranean), showing that they are gregarious in their habits in soft mud. Many examples were dredged showing the whorls disconnected, as in *Vermetus*. Fifty species are described of world-wide distribution.

When young, the shell of the genus *Cæcum* is discoidal; when adult, it becomes decollated, and appears to be simply tubular, cylindrical, with a round entire aperture, the apex being closed by a mamillated septum, marking the point where the original spire has been cast off. This curious little genus has puzzled many zoologists, having been referred to the Pteropods, to the *Orthoceratites*, &c. Two British species have been met with living in about ten fathoms water.

In the genus *Vermetus*, or the "Worm-shell," the shell is tubular and attached, but when young it is regularly spiral, but always disunited and irregular in its adult growth. The tube is repeatedly partitioned off, the aperture is round, the operculum circular and concave externally. The animal has a rudimentary cylindrical foot, being unable to crawl or glide, as the shells are fixed together in clusters. *Vermetus* is found on the coasts of Portugal, the Mediterranean, Africa, and India.

The genus *Siliquaria* has a tubular cylindrical shell, irregularly twisted; its apex is spiral, the aperture is circular. In *Siliquaria* the notch for the siphon remains unclosed, so that as the shell grows it prolongs the fissure through the whole length of its tube. This genus was formerly regarded as an Annelide, but its mulluscous nature was demonstrated by M. Andouin. The typical species is found in the Mediterranean, living embedded in sponges with silicious spicules. Eight species are recorded.

VERMETUS LUMBRICALIS.
(A) Young Shell: (B) Adult Shells.

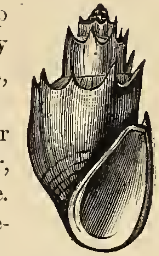
FAMILY XV.—MELANIADÆ.

The shells of this family are spiral, turreted, covered with a thick dark-coloured epidermis; aperture often channelled, or notched in front; outer lip simple; operculum horny, spiral. The spire is often very much eroded. The animal has a broad, non-retractile muzzle; the tentacles are wide apart; eye-stalks united to bases of tentacles; foot broad and short, angular in front; mantle-margin fringed; tongue long and linear. These animals are mostly viviparous, and all fluviatile, being inhabitants of fresh-water lakes and rivers throughout the

* From *Struthio*, an ostrich, from the aperture being fancifully supposed to resemble the foot of that bird.

warmer parts of the world. In the southern States of North America they are numerous, and form a peculiar group.

The genus *Melania** has its whorls ornamented with striæ or spines; the outer lip is sharp; aperture oval, pointed above; operculum sub-spiral. One hundred and sixty species are distributed along the rivers of the south of Europe, India, the Philippines, and Pacific Islands.



MELANIA AMARULA.

The genus *Paludomus* (*palus*, marsh; *domus*, house) has a smooth turbinated or muricated shell. The spire is small, and usually eroded; operculum horny, lamellar, nucleus external. The animal is like *Melania*, with a fringed margin to its mantle. Ten species are known from Ceylon and India. It inhabits mountain streams, sometimes up to six thousand feet in elevation.

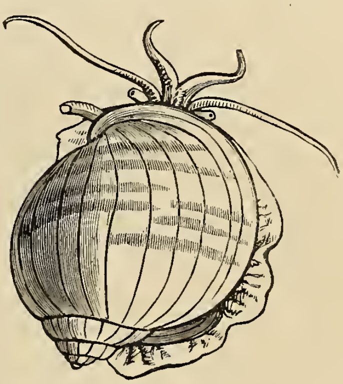
The shell of *Melanopsis* has the last whorl elongated; the spire is short and pointed; the aperture notched in front; the inner lip is thickened; the operculum is sub-spiral. Twenty species of this genus are found in Spain, Austria, Asia Minor, and New Zealand.

FAMILY XVI.—PALUDINIDÆ.

The shells of this family are conical or globular, with a thick olive-green epidermis; the aperture of the shell is rounded and entire; the operculum is horny, or shelly and concentric. The animal has a broad muzzle; the eyes are placed on short pedicels outside the tentacles, which are long and slender. The *Paludinidæ* inhabit fresh water in all parts of the world. The animal of *Paludina* has a small lobe on each side of its neck. It has a long muzzle and very short eye pedicels. The shell is thin, turbinated, umbilicated; the spire is produced; the whorls are round and smooth. The development of the gill-bearing Gasteropods may be easily seen in the common River Snail (*Paludina vivipara*), which bring forth their young alive, and whose oviducts in early summer contain young in all stages of growth, some being a quarter of an inch in diameter. Embryos hardly visible to the naked eye have a well-formed shell, ornamented with epidermal fringes, a foot, and operculum. The head has long and delicate tentacles, and very distinct black eyes. Any one who is interested in mollusca may watch this for himself, as *Paludina* is common in our ditches and marshy waters. Sixty species are described as abundant in rivers and lakes throughout the Northern Hemisphere, Africa, India, China, Manilla, and elsewhere.

LINGUAL TEETH OF AMPULLARIA.† (*After S. P. Woodward.*)

Valvata piscinalis is a little fresh-water mollusc, which has the foot divided in front into two lobes. The shell is round and horny, much shorter than *Paludina* or *Bithynia*. The animal deposits her eggs in a little leather bag, which she hangs on stones or the stems of water-plants, where they remain till they are hatched, and liberated from their bag by the bursting of its rotting sides. They all leave their prison in company, being united in a floating mass of jelly.



AMPULLARIA CANALICULATA.

The *Ampullaria*, or "Apple Snail," has a globular shell with a small spire. The body whorl is large and ventricose; the operculum is shelly; the left neck-lappet is formed into a long incurrent siphon; the muzzle is developed into two long processes, like horns; the tentacles are extremely long and slender. *Ampullaria* inhabits lakes and rivers in the tropics. They retire deep into the mud in the dry season, and are capable of surviving a long drought, having been known to revive after being kept for several years out of water. In Lake Mareotis, and at the mouth of the Indus, Ampullariæ are abundant, mixed with marine shells. Their eggs are large, enclosed in capsules, and form globular masses. Fifty species have been described from South America, West Indies, Africa, and India.

* *Melania*, blackness. † For description of the Snail's tongue, or "odontophore" (tooth-bearer), see page 222.

In *Amphibola* the shell is globular; the columella fissured with a channel near the suture of the outer lip; the operculum is sub-spiral and horny. The animal is without tentacles; the eyes are placed on round lobes. It is an air-breather. *Amphibola* inhabits salt marshes near the sea, living shells having *Serpulæ* attached to them. They are found on the shores of New Zealand in great abundance, living in pools of brackish water, and burying themselves alive at certain seasons in the sandy mud. They are largely eaten by the New Zealanders.

FAMILY XVII.—LITORINIDÆ.

The mantle of animals of this family has a rudimentary siphonal fold; the gills are unequal, one very large; the head is muzzle-shaped, and the eyes are fixed at the outer bases of the tentacles; the foot is grooved along the under surface, and has a linear fold in front; the tongue, which is long, is furnished with seven rows of hooked teeth. The shell is spiral, top-shaped, or flattened; aperture simple in front, never pearly; operculum horny, spiral, the whorls are few.

*Genus Litorina.** The Periwinkle has a compact, solid, turbinate (top-shaped) shell of few whorls; the spire is short, the aperture nearly circular, without any siphonal channel; the outer lip is simple and sharp-edged. The horny operculum fits it most exactly. The *Litorina litorea* is collected in immense quantities around our shores, and is known by the familiar name of "winkles," or "pin-patches." This species is *oviparous*†, and inhabits the lowest zone of seaweed between tide marks. The *Litorina rudis* frequents a higher region, where it is scarcely visited by the tide; it is *viviparous*,‡ and the young have a hard shell before birth, in consequence of which the species is not eaten.

Both the *Litorina* and *Trochus* are the food of the Thrush in the Hebrides during winter. Periwinkles are largely employed by oyster growers to keep the beds and the "culch"§ clean by eating up the slimy green weed that grows so abundantly on oyster beds, especially in hot weather.

More than forty species of Periwinkles are found living on the sea-shore in all parts of the world. When near the mouths of rivers (or as in the Baltic, which is less salt) they come in contact with fresh water, and are liable to become distorted.

In the caves of Southern France and Italy, along with mammoth and reindeer bones and ivory, and in the sepulchral deposits at Aurignac, have been found shell necklaces or bracelets made of the *Litorina litorea*, still abundant on the shores of the Atlantic, along with perforated shells of the Miocene period, evidently gathered in a fossil state to be converted to purposes of personal decoration. In the Megalithic tomb discovered in the year 1838 under the Knock-Maraidhe Cromlech, in the Phœnix Park, Dublin, were found two male skeletons, underneath the skulls of which lay a number of the common *Litorina litorea*, bored evidently for the purpose of being strung together as neck ornaments.

Genus *Fossarus*. This little shell is perforated, the spire is ribbed and striated, the inner lip is thin, the operculum is not spiral. Its distribution is India, West Africa, and the Mediterranean.

The genus *Lacuna* has a short spire, the shell is thin, the aperture is very large, the columella is flattened and umbilicated; it has a spiral operculum. The animal has lateral wings to its opercular lobes and tentacular filaments. The species inhabit the northern shores of Norway, Britain, and Spain, extending from low water to fifty fathoms.

Genus *Litiopa*.|| This minute shell has a pointed spire, the aperture notched in front, the outer lip thin; it has a spiral operculum. They are found floating on seaweed in the Atlantic and Mediterranean; they adhere by delicate threads.

The genera *Cheletropis* and *Macgillivrayia* are also found gregarious in the open sea, and have been referred to the *Pteropoda* by some, but Dr. S. P. Woodward refers them, in his later MS. notes, to the Litorinidæ.

Genus *Rissoa*. This minute white shell (named after Risso, a French zoologist) is conical pointed

* From Latin, *litus*, *litoris*, the sea-shore.

† Oviparous, from *ovum*, an egg, and *pario*, to lay eggs.

‡ Viviparous, from *vivus*, living, and *pario*, *i.e.*, the young are born alive, as in *Paludina*.

§ Any foreign body to which the young Oyster attaches itself when it ceases to be a free swimmer.

|| Greek, *litos*, simple, and *ope*, aperture.

and many-whorled, some species being smooth, others ribbed or cancellated; aperture roundish, the operculum sub-spiral. The animal has its eyes on small prominences near the outer base of the tentacles, which are long and slender. The foot is pointed behind. The Rissoæ abound in shallow water on seaweed, and live down to a depth of 100 fathoms. Seventy species have been described; they are cosmopolitan in distribution.

Genus *Lithoglypus.* This small shell has few and smooth whorls, and a large entire aperture. The outer lip is sharp; the operculum is ovate and few-whorled. It has an olive-coloured epidermis. It is found living in the Danube and Central Africa in fresh water. The shell is often eroded. D'Orbigny has described it from South America, under the name of *Paludestrina.* Seventeen species have been noticed.

Genus *Truncatella,* Looping Snail. This shell is cylindrical and truncated; aperture oblong-oval; operculum very thin and somewhat spiral. The species of this genus inhabit the East and West Indies, Britain, the Mediterranean, and the islands of the Corean Archipelago. The animals are amphibious in their habits, being sometimes found under heaps of seaweed on the shore, and sometimes in shallow water. In the Corea they live gregariously, by many thousands, in the holes of decayed rock and coral which border, in many places, the islands; the spots they occupy are always exposed to the spray of the sea. (Adams.)

FAMILY XVIII.—CALYPTRÆIDÆ.

The "Bonnet Limpets." These shells have a more or less spiral apex, and, Limpet-like, adhere to foreign bodies. The interior of the shell is simple, more divided by a shelly process, to which the muscles are attached. The head of the animal is distinct, the muzzle is long, and the eyes are at the outer base of the tentacles.

"The Bonnet Limpets are found adhering to stones and shells; most of them appear never to quit the spot on which they first settle, as the margins of their shells become adapted to the surface beneath, while some wear away the space beneath their foot, and others secrete a shelly base. Both their form and colour depend on the situation in which they grow; those found in the cavities of dead shells are nearly flat, or even concave above, and colourless. They are presumed to feed on the seaweeds growing round them, or on animalcules. A *Calyptræa* which Professor Forbes kept in a glass ate a small Sea Slug (*Ganiodoris*), which was confined with it. Both *Calyptræa* and *Pileopsis* sometimes cover and hatch their spawn in front of their foot." (S. P. Woodward.)

Genus *Calyptrea,** "Cup and Saucer Limpet." The shell is conical, with a minute spiral nucleus; the margin is irregular; interior provided with a half cup-shaped process, attached to the apex; outer surface of shell rough. The Cup and Saucer Limpets are found under stones in shallow water, between tide-marks. Fifty species are known of almost world-wide distribution.

Genus *Crepidula,* "The Slipper-shell." This shell is oval and Limpet-like; the apex is near the posterior margin; the interior has a shelly partition covering its posterior half. The Crepidulæ are sedentary on stones and shells in shallow water, and are sometimes found adhering to one another in groups of many successive generations. The specimens or species which live inside empty spiral shells are very thin, nearly flat, and colourless. Forty species occur recent, in the West Indies, Mediterranean, Cape of Good Hope, Australia, and America.

Genus *Pileopsis.*† The shell of the Bonnet Limpet is conical; the apex is behind, and is spirally curved; the aperture is rounded; the muscular attachment is shaped like a horseshoe. The animal has a fringed margin to its mantle. *P. ungarica* is found on Oysters. Seven species are living in Britain, Norway, the Mediterranean, East and West Indies, Australia, &c.

Genus *Hipponyx.*‡ The horseshoe shell is thick, conical, oblique; its apex is behind; it has a shelly base, bearing a horseshoe-shaped impression. Seventy species are found living in the West Indies, Galapagos, the Philippines, Australia, &c.

Genus *Phorus.*§ The shell is, like Trochus, concave beneath and irregular; the whorls are flat, and more or less concealed by fragments of shell and stones; the spire is depressed, the aperture wide, the umbilicus small; it has a thin oval operculum. "The 'Carriers' inhabit deep water, and are

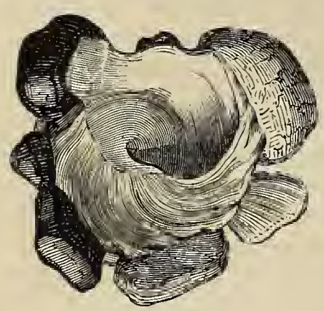
* Latin, *calyptra,* a lady's cap.

† Greek, *pileos,* a cap, and *opsis,* like.

‡ Greek, *hippos,* a horse, and *onyx,* a hoof.

§ Greek, *phoreus,* a carrier. They are also called grotto-shells

most numerous in the Javan and China Seas. Each species appears to have its own peculiar method of collecting the fragments of shells and stones which cover the ground where it lives, and each cements to the outside of the shell its particular kind of materials. The adventitious pieces of shell are so disposed as not to curve downwards beyond the edge of the shell so as to impede the progress of the animal, but are usually placed with their concave side uppermost." (Adams.) Nine species have been described; they are all tropical. Some species of these shells prefer to affix stones, whilst others select dead shells or corals for their grottoes. The former are called "mineralogists" and the latter "conchologists" by collectors.



PHORUS CONCHYLIOPHORUS.

FAMILY XIX.—TURBINIDÆ.

In this family the shell is turbinate, the last whorl rounded and ventricose; aperture sub-circular, inner lip smooth and simple; operculum round, horny, with a solid convex shelly coat. In the great pearly *Turbo marmoreus*, so often used for a sideboard or mantelpiece ornament, the operculum frequently weighs several ounces. A specimen in the Shell Gallery of the British Museum weighs more than half a pound. The animal has a short proboscis; the eyes are at the outer base of the tentacles, which are long and slender; the head and sides are bordered by fringed lobes and filaments.

The shells of nearly all of the Turbinidæ are brilliantly pearly when the epidermis and outer layer of shell have been artificially removed.

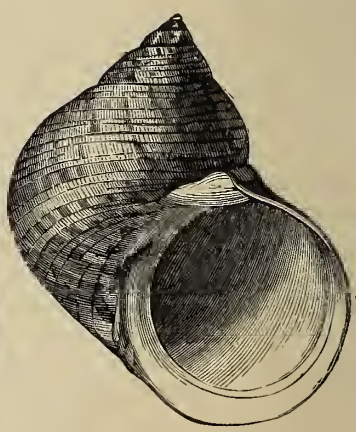
Genus *Turbo*.* The shells of *Turbo* have solid convex whorls, often ornamented by furrows or tubercles; the aperture is large and rounded, the shell is pearly within. The outer side of the operculum in some species resembles tufa deposited by a petrifying spring; they are sometimes used for ornaments.

The Turbos inhabit the tropical seas; sixty species have been described. They are mostly littoral.

Genus *Phasianella*, the "Pheasant-shell." The spire of this shell is elevated, the whorls are smooth and polished, the aperture oval, the columella flattened, and the outer lip thin.

"When the animals of this genus crawl, the foot appears to be divided longitudinally into halves, which advance alternately; when the right side moves the left remains stationary, and when this in turn is carried forward the other half serves as a point of support. MM. Audouin and Milne-Edwards have observed that *P. pullus* exhibits the same mode of progression, which they compare to the amble or canter of a horse. In *Phasianella* proper the tentacles are provided with three cirrhi. In the smaller species, forming the *Tricolia* of Risso, the head-lobes appear to be wanting. The larger species, all of which have beautifully variegated shells, are principally from Australia and the islands of the Pacific, and the smaller species are from the West Indies and the Mediteranean." (Adams.) Thirty species are known living.

TURBO ARGYROSTOMUS.



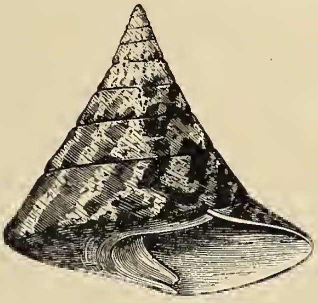
TURBO IMPERIALIS.

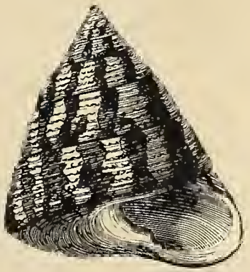
Genus *Imperator*. The shell is like a *Trochus*, with a flat or concave base; the whorls are keeled or stellated; seen from above, it resembles the rowel of a spur, hence the name Spur-shell. The shell is pearly within, the operculum is oblong and shelly. Twenty species are known, from South Africa, India, &c.

* Latin, *turbo*, a whipping-top.

Genus *Trochus*.* The shells of this genus are pyramidal, with a nearly flat base, the whorls are variously striated, the aperture is squarish and pearly inside, the outer lip is thin, the operculum is composed of many convolutions. There are 150 known and described species of this world-wide shell, extending from low water to more than 100 fathoms.

Genus *Elenchus.* The shell in this genus is thick and polished, and there is usually a single tooth at the fore part of the columella; the aperture is vividly iridescent within, and the surface is often ornamented with varied and beautiful markings. This species is characteristic of Australia; fifteen have been described. They are polished and worn by the natives of North-east Australia as necklaces.


TROCHUS NILOTICUS.


TROCHUS VIRGATUS.

Genus *Rotella,* "the Button-shell." The shell is like porcelain, the whorls round and polished, the base or umbilicus covered with a large callosity, aperture small, outer lip acute. The upper part of the shell is banded with lines of colour. Eighteen species are recorded, from India, the Philippines, China, and New Zealand.

Genus *Monodonta*, the "Rosary-shell." It is top-shaped, like the common Periwinkle in form; the whorls are grooved and granulated spirally, lip thickened and grooved, columella irregularly toothed, operculum whorled and horny. Ten recent species are known from West Africa, Red Sea, India, and Australia. They inhabit mangrove swamps.

Genus *Delphinula.* The shell has few whorls, the apex is depressed, the angles of the whorls are rugose or spiny, the aperture is round and pearly within, the umbilicus is open, the operculum horny and many-whorled. *Delphinula* is found living on coral reefs at low water. Twenty species have been described, from the Red Sea, India, the Philippines, China, and Australia.

Genus *Cyclostrema.* This little shell differs from *Delphinula* in being nearly discoidal; the whorls are cancellated or cross-ribbed, and the inside of the shell is not pearly. Eighteen species are recorded, living in five to twenty fathoms water, at the Cape, India, the Philippines, &c.

Genus *Stomatella.* The shell has a minute spire and a very large oblique aperture; the interior is pearly; lip thin and even; operculum circular, horny, spiral. Twenty recent species are described, from the Cape, India, Australia, &c. The genus *Gena* differs but little from the preceding one, save in the absence of the operculum. Sixteen species have been described, mostly from the Philippine Islands, where they appear to represent the genus *Haliotis.*

FAMILY XX.—HALIOTIDÆ.

This shell is ear-shaped and spiral; the aperture is very large, pearly and iridescent within; perforated with a series of holes; there is no operculum.

HALIOTIS TRICOSTALIS.
(*p*) Perforation for syphon.

The animal has a short broad head, with eyes on stout stalks at the outer base of the tentacles; the left lobe of the mantle elongated into an anal siphon, occupies the anterior perforation of the shell; the foot is large, and very thick, with serrated lobes and filaments on the outer edges. With the true Ear-shells (*Haliotidæ*) are placed such of the Trochiform shells as have a notched or perforated aperture.

Genus *Haliotis*,† "Ear-shell." The shell has a small flat spire and a very wide iridescent aperture; exterior striated, corrugated, and dull, often incrusted with corallines, &c.; outer angle perforated by a series of holes, which are successively closed. Seventy-five living species are known; they inhabit the littoral zone, and occur in Britain, the Canaries, India, Australia, and California, &c.

In the Ear-shell (*Haliotis*), found living on the rocks at low water in the Channel Islands and elsewhere, and so common a mantelpiece ornament, on account of its pearly interior, the ex-current

* Latin, *trochus*, a hoop. † Greek, *halios*, marine, and *ous*, an ear.

siphon is accommodated by a hole near the lip of the shell, repeatedly renewed with the growth of the animal. In the Keyhole Limpet (*Fissurella*) the anal siphon passes through the perforation on the summit of the shell. The *Haliotis* abounds on the shores of the Channel Islands, where it is called the "Ormer," and is cooked, after being well beaten to make it tender. It is also eaten in Japan.

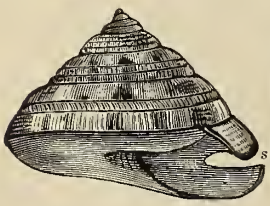
The late Mr. Daniel Hanbury, F.L.S., published some interesting "Notes on Chinese Materia Medica," in the *Pharmaceutical Journal* for February, 1862, from which I extract the following:—"*Shih-keue-ming;* shells of *Haliotis funebris*, Reeve; *Puntsaon*, &c. This shell is stated to occur on the coasts of Fuh-kien and Kwantung. Messrs. Cuming and Lovell Reeve (both since deceased), who have examined it, concur in referring it to *Haliotis funebris*, a New Holland species, figured by the latter gentleman in his beautiful *Conchologia Iconica*, sect. *Haliotis*, pl. xii., fig. 38. The shell of *Haliotis* is also much used for inlaying *papier mâché* work, &c. The section of any pearly shell exhibits an immense succession of fine and smooth layers. If polished or worn ever so little, these laminæ will be cut through, and their edges will present a series of parallel lines. In the nacreous shell of *Haliotis* the layers are corrugated, so that a single layer might serve to give the pearly effect. In porcellanous shells the entire structure is composed of layers of cells, much metamorphosed, arranged in three distinct strata, the direction of each of which is different. When seen in section, each stratum is found to be composed of many vertical plates, arranged sometimes transversely, sometimes lengthwise, according to the genus."

Genus *Stomatia*. The shell of *Stomatia* resembles *Haliotis*, but has no perforations, merely a simple furrow; the surface is rough and spirally ridged; the apex of the spire, which is small, is very prominent; the opening of the shell is wide and pearly within. Twelve species have been met with under stones at low water. Its distribution is the coasts of Java, Philippines, Torres Straits, Pacific.

Genus *Scissurella*.* This minute shell is thin, with a large body whorl and a small spire; surface striated; the aperture rounded, but not pearly, with a slit in the margin of the outer lip; the operculum is ovate and very thin, obscurely sub-spiral.

The animal is like *Margarita*, with long and pectinated tentacles, the eyes at their base; foot with two pointed lappets and two long, slender, pectinated cirrhi on each side. No part of the animal was external to the shell. The only living example occurred at Hammerfest in forty to eighty fathoms water. When placed in a glass of sea water, it crawled up the side and scraped the glass with its tongue. It was pale and transparent when living, but turned inky black after immersion in alcohol. (Barrett.) The *slit* in the young shell is converted into a *foramen* in the adult, as in the Jurassic *Trochotoma*.

Genus *Pleurotomaria*,† "Slit-shell." The shell is like Trochus, it has few whorls; the surface is variously ornamented, the aperture sub-quadrate, having a deep slit in the outer lip. As the shell grows this slit is gradually filled up, and forms a distinct band round the whorls of the shell; it is not pearly. This is probably the rarest of all living sea-shells. Only two species have been obtained: one from the Antilles and one from the East Indies. Four hundred species occur fossil, chiefly in the Oolites.



PLEUROTOMARIA QUOYANA.

(s) The slit.

PLEUROTOMARIA PLATYSPIRA.

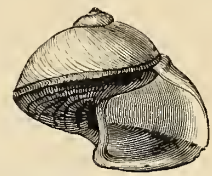
FAMILY XXI.—IANTHINIDÆ.

In this family the characters are: shell thin, translucent, spiral, more or less turbinate, with a sinistral nucleus; head short and thick; tentacles obtuse; eye pedicels pointed, but without eyes; gills plume-like, exposed; foot small, flat, rudimentary, having a raft-like appendage attached to the hinder part; habits pelagic.

Genus *Ianthina*,‡ "Violet Snail." Prof. Sir Wyville Thomson writes: "The genus *Ianthina* inhabits a spiral shell, like a Snail-shell, of a most lovely blue. *Ianthina* floats by, spreading out its 'foot' on the surface, but it is more usually found attached to the different kinds of 'Portuguese men-of-war,' *Velella*, *Physalia*, and

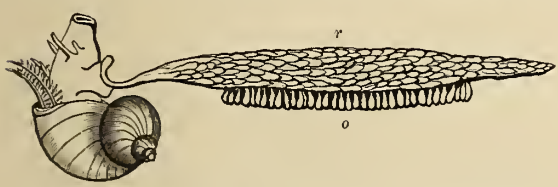
* Latin, diminutive of *scissus*, a slit. † Greek, *pleura*, side, and *tome*, notch. ‡ Latin, *Ianthina*, violet-coloured.

Porpita, or in the mid-Atlantic in the wandering islands of gulf-weed. At certain seasons a peculiar kind of membranous float or raft is secreted from the animal, like a crescentic piece of honey-comb, with the cells filled with air. The egg-sacs, which are not unlike those of the common Whelk, are attached beneath the float, and when the float is complete, and the egg-sacs full, the creature disengages it, and leaves the eggs to be hatched as it drifts about on the surface in the warmth and sunlight. The shells of *Ianthina* are common in the 'globigerina ooze.' They are not unfrequently cast up on the shore on the west coasts of Ireland and of Scotland, and even on the Shetland and Faroe Islands. They are not, however, inhabitants of our northern seas. They are drifted along and scattered about by our beneficent ameliorator, 'the Gulf-Stream.'" (*Challenger*, Vol. I., p. 119.)



IANTHINA COMMUNIS.

"The *Ianthinæ*," says Dr. S. P. Woodward, "are gregarious in the open sea, where they are found in myriads, and feed on the small blue acalephæ (*Velella*). They are frequently drifted to the southern and western British shores, especially when the wind continues long from the S.W.; in Swansea Bay the animals have been found quite fresh. When handled they exude a violet fluid from beneath the margin of the mantle. In rough weather they are driven about and their floats broken or detached, in which state they are often met with. The capsules beneath the further end of the raft have been observed to be empty at a time when those in the middle contained young with fully-formed shells, and those near the animal were filled with eggs. They have no power of sinking or rising in the water. The raft, which is much too large to be withdrawn into the shell, is an extreme modification of the operculum." Six species have been described, from the Atlantic and Pacific.



IANTHINA AND ITS RAFT. (*r*, The Raft; *o*, the Egg-capsules.)

FAMILY XXII.—FISSURELLIDÆ.

The shell is conical and symmetrical, shaped like that of a Limpet, but with the apex curved, the front margin notched, or the top perforated; muscular scar semicircular, open in front. The animal has its eyes at the base of the tentacles, which are somewhat broad; the head has a short muzzle; the anal siphon occupies the notch in the shell in front, or passes through the hole in the summit of the shell; the teeth are like those of *Trochus*. It is a vegetable feeder.

Genus *Fissurella*.* "The Keyhole Limpet" has an oval conical shell, with a perforation in the top; the surface is cancellated with intersecting lines; in very young shells the apex is nearly spiral and the perforation in front of the apex, but the hole increases in size, and the summit gradually disappears. The *Fissurellæ* mostly inhabit the laminarian zone, but have a range from low water to fifty fathoms. One hundred and twenty species are described. They are cosmopolitan.

Genus *Macroschisma*. In this shell the perforation for the anal siphon is close to the hinder margin of the shell. The animal is far larger than its shell. It is found in the Philippines and West Australia.

Genus *Puncturella*. In this little shell the fissure is placed in front of the recurved apex; the shell is conical, and the surface is furrowed. Two species inhabit Greenland, Norway, and North America. It is also found at Tierra del Fuego, and both living and fossil in Britain.

Genus *Rimula*. The shell in *Rimula* resembles that in *Puncturella*, but is more oblong, and the perforation is near the anterior margin. Its habitat is the Philippines, and its range from low water to twenty-five fathoms.

Genus *Emarginula*.† This pretty little cancellated form has no hole in its shell, but the front margin has a deep slit for the anal siphon. Twenty-six species are found living from low water to ninety fathoms on the coasts of Britain, Norway, the Philippines, Australia, &c.

Genus *Parmophorus*,‡ Duck's-bill Limpet. The animal is very large compared with its shell, which

* Latin, diminutive of *fissura*, a slit. † Latin, *emarginata*, notched.

‡ Greek, *parme*, a shield and *phoreus*, a bearer.

is oblong, smooth, and white, but without perforation or notch, and is permanently covered by the mantle of the animal, which is black. It inhabits shallow water under stones. Ten species are described from the Red Sea, the Philippines, Australia, &c.

FAMILY XXIII.—NERITIDÆ.

The spire is very small and depressed, the shell is thick and round. The animal absorbs the internal portion of its shell to give room to the soft parts of its body; the aperture is half round, the columella is flattened, the operculum shelly, sub-spiral, and is articulated to the shell by a remarkable hinge-like process. The head of the animal is short and broad, the eye-stalks are prominent, the outside tentacles long and slender; the foot is oblong and triangular.

Genus *Nerita*. The shell has a horny epidermis, a thick outer lip, toothed within, and a broad and flat columella, the inner edge of which is straight and toothed. The Nerites are found in all the warm seas of the globe; they inhabit the littoral zone. One hundred and sixteen species have been described.

Genus *Neritina*. The fresh-water Nerites, like the marine Neritas, have a rather thick shell, with a sharp outer lip and a straight toothed inner one; the operculum is shelly, with a horny border, toothed on its straight side.

The Neritinæ are small globular shells, ornamented with a great variety of black or purple bands and spots, covered with a polished horny epidermis. They are mostly confined to the fresh waters of warm regions. One species (*N. fluviatilis*) is found in British rivers and in the brackish water of the Baltic. Another extends its range into the brackish water of North American rivers; and the West Indian *N. viridis* and *meleagris* are found in the sea. (S. P. Woodward.) Another form is found in the brackish waters of India. *N. corona* (the Crowned Nerite), from Madagascar, is ornamented with a series of long tubercular spines. One hundred species are found living, and twenty fossil. "*Neritina sulcata* is found on the foliage of tall trees, many hundreds of yards from the river's bank in the Celebes." (Adams.)

The genus *Navicella* has a smooth, oblong, Limpet-like shell, with a small columella-shelf beneath; the operculum is very small and shelly; the shell is covered by a dark olive epidermis. The "boat-shells," as they are called, inhabit fresh waters, adhering to stones and water-plants. Twenty-four species are described.

FAMILY XXIV.—PATELLIDÆ.

The Limpets have conical shells, the apex of which is turned towards the front; they have a horseshoe-shaped muscular scar inside. The head is provided with tentacles having the eyes at their outer bases, the foot is as large as the edge of the shell,. the gills are concealed at the back of the head, the tongue is ribbon-like and of great length.

Genus *Patella*.* In *Patella* the shell is usually oval and tent-shaped, the interior smooth, but not pearly, the outside rough or having radiating ribs, the margin sometimes spiny.

The tongue of the Limpet is longer than its shell; it has 160 rows of teeth, twelve in each row, or 1,920 in all. *Patella variegata*, two inches and a quarter long, has a tongue twelve inches and a half long. (Blanford.) The Limpets inhabit rocks between tide-marks, and are left dry twice every day. They adhere firmly like a sucker to the rock, and it is difficult to detach them without breaking their shells. They always return to the same spot after feeding, and the place where they rest, even on very hard rock, is found to be worn into a smooth concavity beneath the foot of the animal, and the margin of the shell exactly fits the inequalities of the surrounding surface. The Limpets are all vegetable feeders. One hundred living species have been described. They are world-wide in distribution. The *Patella*, or Rock Limpet, is much used by fishermen for bait. On the coast of Berwickshire nearly twelve millions have been collected yearly, until their numbers are so decreased that collecting them has become tedious. In the north of Ireland they are used for human food, especially in seasons of scarcity. Many tons weight are collected annually near the town of Larne alone. (Patterson.)

The "Oyster-catcher" (*Haematopus ostralegus*), a well-known sea-shore bird, does not subsist upon the Oyster, as its name implies, but chiefly upon the Rock Limpet. The adroitness

* Latin, *patella*, a dish.

which he displays in undermining these far exceeds the rapidity of the most practised oyster-opener at a London fishmonger's shop.

On the western coast of South America there is a Limpet which attains the diameter of a foot, and is used by the natives as a basin.

FAMILY XXV.—DENTALIADÆ.

Genus *Dentalium*, "Tooth-shells." The shell is like a curved tube, open at each end, gradually increasing in size from the posterior to the anterior end; the surface is either smooth or ribbed longitudinally; the mouth is round (not contracted at the aperture, like the genus *Ditrupa*, which is an annelide). The animal is attached to its shell near the smaller end; the head is rudimentary, the eyes and tentacles are wanting, the mouth is fringed, the foot is pointed. The *Dentalia* are all animal feeders, devouring foraminifera and minute bivalves; they bury themselves in the mud, and range in depth from ten to 100 fathoms. Their distribution is nearly cosmopolitan. Thirty living species are known.


DENTALIUM ELEPHANTINUM.

In the Cavern of Bruniquel, Valley of the Aveyron, Department of Tarn-et-Garonne, several shells have been found, evidently collected and used by the pre-historic occupants as ornaments. These included *Dentalium*, *Natica*, *Nassa*, *Pectunculus*, *Scalaria*, *Voluta*, and *Cypræa*, several of which had been perforated.

Corresponding to the Cowry currency of Asia and Africa is the American Ioqua, or *Dentalium*, a shell found chiefly at the entrance of the Straits of De Fuca, and employed both for ornament and money. The Chinooks and other Indians of the Northern Pacific coast wear long strings of Ioqua shells as necklaces and fringes to their robes. These have a value assigned to them, increasing in proportion to their size, which varies from about an inch and a half to upwards of two inches in length. Mr. Paul Kane writes:—"A great trade is carried on among all the tribes in the neighbourhood of Vancouver Island through the medium of these shells. Forty shells of the standard size, extending a fathom's length, are equal in value to a beaver's skin; but if shells can be found so far in excess of the ordinary standard that thirty-nine are long enough to make a fathom, they are worth two beavers' skins; and so on, increasing in value one beaver skin for every shell less than the first number."


CHITON MAGNIFICUS.

FAMILY XXVI.—CHITONIDÆ.

Genus *Chiton** (Linnæus). Unlike the other Mollusca already described, the shell of Chiton is made up of eight imbricated plates, fixed transversely on the back of the animal, which enable it, when caught, to roll itself up like a Wood-louse or an Armadillo; the border of the mantle is bare, or covered with minute plates, hairs, or spines. Like the Limpets, the Chitons have a broad creeping disc; they have a long series of lingual teeth, but no eyes or tentacles. More than two hundred species occur, living all over the world, from low water to a hundred fathoms.

ORDER II.—PULMONIFERA.†

In this order are placed all the air-breathing Snails. Many of them have forms externally similar to the Sea Snails, whose tribes we have already enumerated; but they differ in this essential character: that whereas the BRANCHIFERA carry on their respiration in water by gills or membranes (like fishes), and, as a rule, lead an aquatic existence, the PULMONIFERA admit *air* into their breathing chamber, which is lined with finely-branching vessels, and is, in fact, a simple form of lung; and they mostly lead a terrestrial existence.

In the Pulmonifera, or Air-breathing Snails, provision is made for the admission of air directly into a respiratory chamber (*m*) formed by the mantle. In some of the Slugs this is placed at the hinder extremity of the body, as in *Testacella*, in the others at one side of the mantle; and in the Garden Snail the aperture is nearly in front, beneath the mouth of the shell (*n*). The mouth (*a*) has a

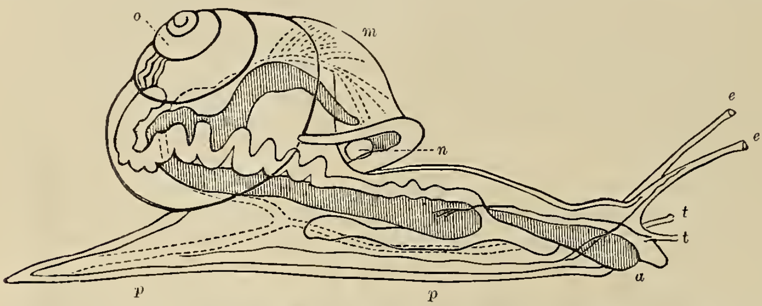
* Greek, *chiton*, a coat of mail.

† Latin, *pulmo*, a lung; and *fero*, I bear or carry.

horny upper jaw, and is also provided with an *odontophore*, bearing an excellent set of lingual teeth. (See p. 222.)

The air-breathing Snails are, as a rule, vegetable feeders, and form two great divisions.

Division a. INOPERCULATA,* or Snails without an operculum. This division embraces a great proportion of the terrestrial Snails. They usually have well-developed shells, sufficiently large to conceal the entire animal; and although, as a rule, they flourish most in warm humid regions, where vegetation is abundant, they are found even in very dry and arid regions, and are able to survive under conditions which would at first sight appear fatal to any soft-bodied mollusc.



ANATOMY OF THE COMMON GARDEN SNAIL.

a, mouth; *pp*, foot; *ee*, Eyes; *n*, Orifice opening into Pulmonary Cavity; *m*, Branchiæ; *tt*, Tentacles; *o*, Position of Ovaries; the Shaded Part is the Stomach and Intestines; the Single Lines are Nerves, the Dotted Lines Blood-vessels.

Thus, for example, my late colleague, Dr. Baird, F.R.S., of the Zoological Department, British Museum, records (in the *Annals and Mag. Nat. Hist.* for 1850) that, having received some specimens of the "Desert Snail" from Egypt, he fixed them with gum mastic to a tablet on 25th March, 1846; on 7th March, 1850, it was found that the Snail had come out of his shell, and had discoloured the tablet with his slime in his endeavours to free himself. Failing to do this, he had again retired, closing the mouth of his shell with the glistening film which all Snails make during hibernation (called an epiphragm †). This attracted attention, and Dr. Baird having immersed the Snail-shell in tepid water, the desert wanderer crawled out and walked about, and partook of a lettuce-leaf, and was for a long time the cynosure of an admiring circle of visitors.

In this division are also placed those apparently helpless, but exceedingly wide-awake pests of our gardens, the *Limacidæ*, or Slugs (most of which are quite naked, though a few have a tiny rudimentary shell, often internal).

It also includes a family called *Oncidiadæ*, another named *Limnæidæ* (in which are many of our Pond Snails), and a fifth family, the *Auriculidæ*, inhabiting salt marshes in the tropics.

FAMILY XXVII.—HELICIDÆ.

The Land Snails have a well-developed external shell, into which the entire animal can be withdrawn. These "snail-houses" are exceedingly varied in the form of their spirals, and the whorls are frequently decorated with bright bands of colour; the mouth is often curiously twisted and toothed within. Some show periodic growths. In cold countries Snails hibernate in winter; in hot countries they sleep during the dry season, coming out with the first rain. In both cases the Snail (having no operculum to his shell) makes an epiphragm of hardened mucus, sometimes strengthened with a thin deposit of lime. In this temporary lid a small aperture is left to breathe through, the rest being carefully closed.

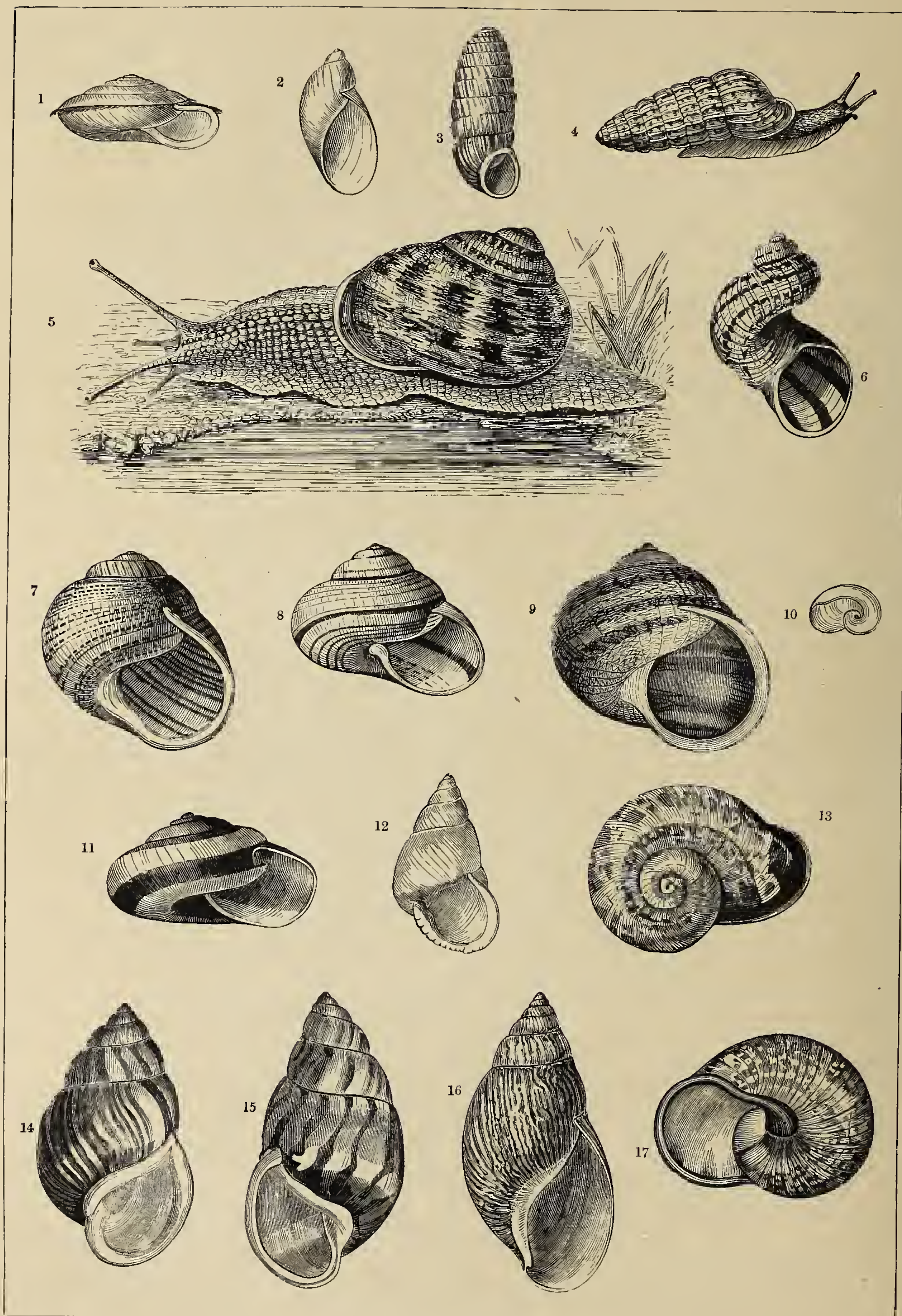
The Snail has a head with four cylindrical, retractile tentacles, of which the upper pair are the longest, and have the eyes at their summits. The breathing opening is on the right side, beneath the margin of the shell. The foot is very distinct, and usually elongated. The mouth has a strong horny upper mandible, and a broad oblong tongue armed with numerous rows of small teeth.

Genus *Helix*. The shells of the Helices vary in form, but are mostly either umbilicated, perforate or imperforate; some are discoidal, or globosely depressed, or conoidal. The aperture also varies greatly in form.

In *Gibbus Lyonetti*, from Mauritius, the shell, after forming five ordinary convolutions, suddenly makes a complete double in its growth, and remains hump-backed for the rest of its

* Latin, *in*, without; *operculum*, a lid.

† Greek, *epi*, upon; *phragma*, a partition.



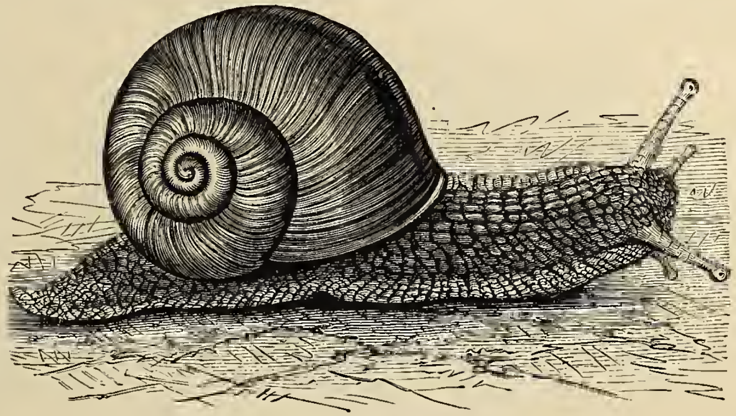
LAND SNAILS.

1, Helix Mackenzii; 2, Succinea putris; 3, 4, Pupa uva; 5, Helix aspersa; 6, H aspersa, var. scalaris; 7, H. undulata; 8, H. Stuartia; 9, H. aspersa; 10, Vitrina fasciata; 11, H. citrina; 12, H. translucida; 13, 17, H. Waltoni; 14, 15, Bulimus sultanus; 16, Achatina zebra.

days. The still more eccentric Land Snail, *Helix* (*Anastoma*) *globulus*, from Brazil, after growing like the ordinary *Helix hortensis*, or *arbustorum*, suddenly pulls up, and, twisting his mouth up tight, produces the aperture on a plane with the spire.

Many of the Land Snails, not furnished with *opercula*, fortify the entrance to their shell by secreting a number of shelly plates, or teeth, around the aperture, so as to lead one to marvel how the occupant of the shell ever managed to get in or out of his own house, and still more how the eggs were excluded.

Snails are world-wide in their distribution, numbering more than 1,600 species. Their northern limits extend as far as trees grow, and south to Tierra del Fuego. Their greatest development is in the warm and humid regions of the globe. They attain in the Andes to an elevation of 11,000 feet, and to 8,000 feet in Ceylon. About fifty species of *Helix* are found fossil in the Tertiary rocks. The Snails found on oceanic islands are mostly peculiar.



HELIX POMATIA.

The Land Snails, such as the *Helix arbustorum* and *H. aspersa*, are the favourite food of the Blackbird and Thrush, and a smaller species of *Helix*, common on sandy pastures, is said by Patterson to be eaten in vast numbers by the sheep when grazing, and to form a very fattening kind of food. Another Land Snail (*Helix pomatia*) was highly esteemed by the Romans, who fattened them as articles of food. They are still found abundantly in many localities in the south of England, especially about the sites of old Roman villas in Gloucestershire. They were at one time appreciated by our ancestors, and when boiled in spring-water, and seasoned with oil, salt, and pepper, they make a dainty dish. Our neighbours the French still eat them extensively, as do also the poorer classes in Spain and Italy; the Brazilians also eat Land Snails. Every one who visits Paris should taste a dish of Snails: they are most delicious.

In summer and winter Land Snails cease to grow. The Snails of the first year, hatched in the spring, usually attain half their growth in the autumn of the same year, and their maturity in the following spring. There is always a stronger line of growth or conspicuous mark on banded and Garden Snails, and in some a rib inside strengthens the rim of the half-grown shell.

Genus *Vitrina*, "Glass-shell." The shell is very thin, the whorls are few, the last is large, with a wide aperture and a thin lip. "In its geographical distribution, the genus *Vitrina* is found in every part of the globe, the species being most numerous north of the equator. They live in moist situations, among loose earth, stones, grass, and moss. They are very lively, crawling constantly about, and, when touched, will sometimes jump several inches from the ground. The tail of the animal is obliquely truncated, and the edge-teeth of the tongue are sharp-pointed." (Adams.)

Genus *Succinea*, "Amber Snail." The animal is large in proportion to its shell; its foot is broad, and the tentacles are short and thick; its shell is like that of *Limnæa* in shape, having a small spiral, but a large aperture; its lingual teeth are like *Helix*. *Succinea putris* has fifty rows of teeth, sixty-five teeth in a row. These Snails inhabit damp places, but rarely enter the water. There are sixty-eight living species in almost all parts of the world.

Genus *Bulimus*. This is a turreted shell, with an ear-shaped aperture, usually simple and smooth, but sometimes toothed; the outer lip often thickened at the border. The animal is like *Helix*. The great *Bulimus ovatus*, from South America, is six inches long; it is eaten in Rio. It deposits its eggs among dead leaves. They have a calcareous shell, and when hatched the young are one inch in length. Six hundred and fifty species, of world-wide distribution, are described.

Genus *Achatina*, "Agate-shell." The shell is like that of *Bulimus* in form, with a twisted columella, truncated in front, with an oval aperture; the lip is sharp. The great African Achatina is the largest land-shell known, being eight inches in length; the eggs are more than an inch long; they have a calcareous shell. They are found in all quarters of the globe. One hundred and twenty species are found living, and fourteen fossil. They are said to burrow in the earth, and to be found at roots of garden bulbs. An *Achatina* kept in confinement refused vegetable food, but ate another Snail.

LINGUAL TEETH OF ACHATINA FULICA. (*After* S. P. *Woodward.*)
l l, Lateral Rows; *c*, Central Row.

In addition to the variously disposed jaws, or cutting-plates of a chitinous or calcareous substance with which nearly all Land and Sea Snails and Cuttle-fishes are furnished, they possess a most characteristic buccal, or mouth apparatus—the "odontophore"* (tooth-bearer), commonly called the "tongue," which is attached to the floor of the mouth. It is partly fibrous, and partly cartilaginous, and is provided with special muscles. The external layer, called the radula, is armed with tooth-like processes (see woodcuts), arranged in one or many series, and additions are being constantly made to its posterior end, which is lodged in a sac. The teeth are thus replaced from behind as fast as they are worn away by friction against the food which they rasp, at the anterior end of the tongue. The muscles are so arranged as to cause this wonderful apparatus to travel, backwards and forwards, over the ends of the supporting cartilages of the mouth, in the fashion of a chain-saw, and thus to rasp any substance to which the teeth may be applied. The whole apparatus is also capable of being protracted or retracted, and may thus give to the extremity of the radula a licking motion, which is quite distinct from the chain-saw movement. Salivary glands are also generally present. (Huxley.)

Genus *Pupa*, "Chrysalis-shell."† The shells of this genus are very small, ovoid, with an obtuse apex, whorls inflated, broadest in mid-growth, narrower in later growth; the mouth is often contracted, and sometimes thickened and toothed; the surface of the shell is closely ribbed with straight fine ridges. The foot is short and pointed behind, the lower tentacles short. *Pupa* has a world-wide distribution; it is common in Europe, North America, and Africa, under stones and in crevices of rocks and trees, or among wet moss, chiefly in chalky districts.

Genus *Cylindrella*, Cylinder-shell. The shells of this genus are either pupiform or cylindrical, many-whorled, sometimes left-handed; in the adult shell the apex is usually lost, a septum or partition being formed within to cover the hole. Shells that have lost their apex are said to be decollated.‡ The aperture is round and expanded. The animal is like *Clausilia*, with a short foot, and the lower tentacles small. Fifty species are known in the West Indies and America.

Genus *Clausilia*.§ These little shells are of a brown colour, with a tall spire swollen in the middle; the whorls are transversely striated; the mouth has a thickened contracted lip, with two shelly plates on the inner lip; all the species are left-handed. Nearly 400 are known in Europe and Asia.

FAMILY XXVIII.—LIMACIDÆ (SLUGS).

The Slugs have no true shell; the head and tentacles are retractile, the respiratory and visceral organs being incorporated within the contractile body of the animal, which differs from the Snails in being straight, not spiral. The first indication of a shell takes the form of a small shield-like plate, covering the breathing organs. This rudimentary shell is usually internal; in Testacella it is external.

"The *Limacidæ* shun the light of day, rarely indulging their voracious appetites, except at night. They inhabit gardens and roadside hedges in damp places, and congregate in cellars and outhouses and under planks and stones, around old walls, pumps, and wells. These remarks apply chiefly to the genera *Arion*, *Geomalax*, and *Limax*, which feed on vegetable matter, though not entirely abstaining from flesh. *Testacella* burrows into the ground to the depth of from two to three feet, and feeds, or

* Snails are hence called ODONTOPHORA by some authors.

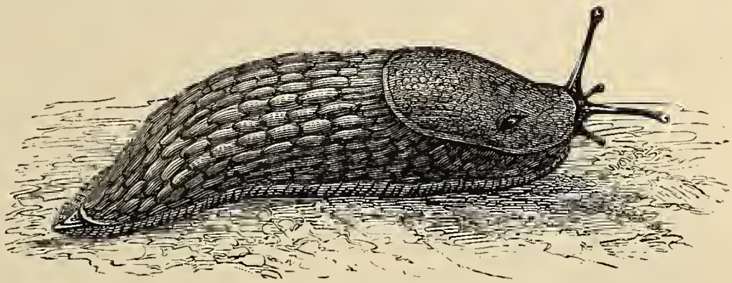
† The oldest air-breathing Snails have been found by Dr. Dawson in the Coal-measures of Nova Scotia, viz., *Pupa vetusta* and *P. vermilionensis*, *Dawsonella Meekié*, and *Zonites priscus*.

‡ Latin, *de*, without; *collis*, a top.

§ Latin, *clausum*, a closed place, in reference to the mouth of the shell.

rather gorges, upon worms. The feebleness of the shell-producing functions in the *Limacidæ* is largely compensated by the faculty of secreting mucus of a particularly viscid kind from all parts of the body. The Slug will lower itself to the ground from a tree or shrub—even from a shelf when brought into a room—by the mere accumulation of mucus at the extremity of the tail hardening into a gelatinous thread. The animal functions are not suspended during hibernation and at other periods, as in the Snail; and the animal is at all times more tenacious of life. The continued secretion of mucus is necessary to the Slug's existence. When this faculty ceases and the integuments dry, the animal dies." (Reeve.)

Genus *Limax*. *Limax* has the foot pointed behind and keeled throughout the back; the mantle is shield-shaped, and placed on the anterior portion of the back; the breathing orifice is on the right side, near the hinder margin of the mantle. The creeping-disc extends the whole length of the animal, but they frequently lift up their heads like the Snail, and move their tentacles in search of objects above them. When alarmed, they withdraw the head beneath the mantle and contract the foot. In dry weather and in winter they bury themselves in the ground. Twenty-two species are found living in Europe and the Canary Islands.



A SLUG. (ARION ATER, "BLACK ARION.")

Genus *Arion*. The Slugs of this genus are distinguished from those of *Limax* proper by the presence of a pore or gland, for the more copious secretion of mucus, at the extremity of the tail, and in having the pulmonary sac and overlapping shield nearer the head, with the respiratory orifice in front. The shield has no internally developed shell, its place being occupied by merely a few calcareous grains, which are sometimes isolated, sometimes aggregated into a rude irregular mass. The body is enveloped by integuments of considerable density, rising into wrinkle-like tuberosities or leaflets, and there is no dorsal keel. (Reeve.) They lay from seventy to one hundred eggs between May and September, which are twenty to forty days in hatching, and attain their full growth in a year. Six species are found in Europe and Africa.

Genus *Parmacella*.* The Parmacella has a large foot, pointed behind; the mantle is small and shield-like in the middle of the back, partially concealing the small oblong and nearly flat shell, which has a sub-spiral apex. There are seven species, found in South Europe, the Canary Islands, and India.

LINGUAL TEETH OF TESTACELLA HALIOTIDES.
(*After a Drawing by S. P. Woodward.*)

Genus *Testacella*. The shell in *Testacella* is small and ear-shaped, and placed at the hinder extremity of the body, which is elongated, broadest behind, tapering towards the small head. Testacella is subterranean in its habits, feeding on earthworms, and visiting the surface only at night. During the winter and dry weather the *Testacella* forms a sort of cocoon in the ground by the exudation of its mucus. If this cell is broken the animal may be seen completely shrouded in its thin opaque white mantle, which rapidly contracts until it extends but a little way beyond the margin of the shell. *Testacella* has been found in gardens in London, at Norwich, and in a field in Devizes. Three species are known in the South of Europe, the Canary Islands, and Britain.

FAMILY XXIX.—ONCIDIADÆ.

The animal is without a shell, and completely covered by coriaceous mantle.

Genus *Oncidium*.† The characters of this genus are, animal tuberculated, oblong, convex, with

* *Greek, parme*, a shield.

† From Greek, *onkos*, a tubercule.

two retractile tentacles, bearing the eyes; more than seventy rows of lingual teeth, 109 in a row, *i.e.*, a single symmetrical tooth in the centre, and fifty-four lateral teeth on each side.

The Oncidia are found living on aquatic plants in marshes in the warmer parts of the world; others frequent sea-shores on rocks near the surface of the sea, ascending and descending as the tide rises and falls. Sixteen species are found in Britain, the Red Sea, Mediterranean, &c.

Genus *Vaginulus.* This animal is like *Oncidium*, but with four tentacles, the lower pair of which is short and bifid. *Vaginulus* inhabits forests, living amongst decayed wood and under leaves. Six species are known in the West Indies, India, South America, and the Philippines.

FAMILY XXX.—LIMNÆIDÆ.

The Limnæidæ, or Pond Snails, are widely distributed over the globe, and are plentiful in individuals, but the species are few, and they are far less varied in the Old World than in the New. We have almost as many species in Britain as exist in all Europe.

Genus *Limnæa.** The shell is ovately turreted, thin, horny; spire elongated and sharply pointed; body-whorl ventricose; aperture large. The animal has a broad short head and flattened tentacles; eyes near the inner bases. The *Limnææ* inhabit fresh water, and feed chiefly on decaying leaves; they deposit their spawn in oblong transparent masses on water-plants and stones. They glide beneath the surface of the water, shell downwards, and hibernate in the mud. Fifty species are found living in Europe, Madeira, India, China, and North America.

LIMNÆA STAGNALIS.

The genus *Chilinia* has a thin oval shell, marked with wavy bands or dark spots; columella plicated and thickened. Fourteen species occur in South America in running water.

The shell of *Physa* is a left-handed spiral; the aperture is rounded in front; the mantle has an expanded margin, bordered with long filaments. Twenty species occur in America, Europe, South Africa, India, and the Philippines.

Genus *Ancylus*, "River Limpet." The shell is Limpet-shaped and thin; the apex left-handed. The animal is like *Limnæa.* Fourteen species are found in running streams, attached to stones and aquatic plants in Europe, North and South America.

PHYSA CASTANEA.

Genus *Gundlachia.* The Shell is thin, obliquely conic; two-thirds of base closed by a flat horizontal plate. It is found in fresh water in Cuba.

Genus *Planorbis.* The shell in *Planorbis* is discoidal; the apex is sunk in the nucleus of the coil; whorls three to seven in number, smooth or striated, sometimes keeled along the border. The body is slender, the head obtuse; tentacles long and bristle-like, with the eyes at their bases; foot small and narrow. "*Planorbis* inhabits all kinds of stagnant pools and ditches and gently running brooks, chiefly adhering to flags and other water-plants. When left dry in the bed of a stream by retiring water, the animal encloses itself within the shell by an epiphragm." (Reeve.) Sixty species occur in Europe, North America, India, and China. It is common in this country.

FAMILY XXXI.—AURICULIDÆ.

The *Auriculidæ* were long regarded as marine shells; they frequent salt marshes, damp hollows, and places overflowed by the sea. They have a spiral shell coated with a horny epidermis; the body-whorl is large, the spire very short; the aperture ear-shaped; the columella plaited. The animal absorbs the internal column of its shell. It has a broad short head with two tentacles, the eyes behind them; orifices as in Snails.

Genus *Auricula.*† The shell has an obtuse spire, covered with a dark epidermis; outer lip expanded and thickened. Fifty species are found living within the tropics, the Philippines, Celebes, and Peru.

Genus *Carychium.* This small mollusc has an oblong, finely striated shell; the aperture oval and toothed. It has two blunt cylindrical tentacles; the eyes are black and near their bases. One species, from the caverns of Carniola, is blind.

* *Limnaios*, Greek, marshy.

† Latin, *auricula*, little ear.

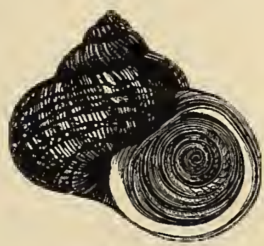
Genus *Siphonaria.* The shell is flattened and tent-shaped, like *Patella*, rugose externally, divided on the right side by a deep siphonal groove, which makes a slight projection on the margin. The *Siphonariæ* live on rocks between the tide-marks. Thirty species are known, almost world-wide.

Division b. Operculata.—Like the preceding division of Land Snails, these are all air-breathers, but they differ in possessing a shelly or horny operculum. They are exceedingly like Periwinkles in appearance. The pulmonary cavity is at the back of the neck, and quite open.

FAMILY XXXII.—CYCLOSTOMIDÆ.

The eyes are slightly prominent on the outer side of tentacles, which are retractile; the foot is elongated, the muzzle long and truncated, mouth simple, operculum spiral.

In the genus *Cyclostoma*, the shell is ovately turbinated, solid, covered with spiral ridges, and minutely reticulated. *Cyclostoma elegans* may be collected in great abundance in the spring of the year in Chalk districts. More than eighty species have been described from South Europe, Africa, and Madagascar.



CYCLOPHORUS, AN OPERCULATED LAND SNAIL.

Many of the land shells are very fine and costly, but the names of species, which are worth from £1 to £3, when in good condition, are far too many to be enumerated. Novelties realise higher prices, like the *Cyclostoma De Burghæ*, which was worth £5 when first brought from Madagascar by Madame Ida Pfeiffer—poor restless soul! A few Snail-shells were all she obtained in compensation for a fever, which terminated her wanderings and her life.

In the genus *Cyclophorus* * the characters are, animal with a short obtuse muzzle, tentacles long, pointed, and slender, foot broad, shell rounded, spire depressed, umbilicate, aperture circular, lip continuous, operculum horny. There are nearly 100 species, which are found in India, the Philippines, &c.

Genus *Pupina.* This curious little *Pupa*-like shell has a circular aperture and a thickened lip, notched before and behind; the operculum is membranous and spiral. Eight species are found in the Philippines, New Guinea, &c.

FAMILY XXXIII.—HELICINIDÆ.

Genus *Helicina.* The shell is flattened, globular; lip simple, expanded; operculum shelly or membranous. The animal resembles *Cyclophorus.* One hundred and fifty species are met with in the West Indies, Philippines, Central America, Pacific Islands, &c.

Genus *Stoastoma.*† All the nineteen species of *Stoastoma* proper are sculptured with spiral lines, and inhabit the island of Jamaica.

FAMILY XXXIV.—ACICULIDÆ.

Genus *Acicula.* The shell is minute and slender, operculum hyaline. *A. fusca* inhabits low marshy situations at the roots of grass. Five species are described as occurring in Britain, Europe, and Vanicoro.

Genus *Geomelania.* The shell is minute, turreted; whorls few, rapidly enlarging; aperture simple, expanded. Twenty-one species are found in Jamaica.

ORDER III.—OPISTHOBRANCHIATA.‡

In this division the animal's gills are not contained in a special cavity, but are exposed on the back and sides towards the rear of the body. When alarmed or removed from their native element, they retract their gills and tentacles, and present the appearance of a lump of jelly.

Division a. Tectibranchiata. The shell is rudimentary, and sometimes wanting; the gills are covered either by the shell or mantle.

FAMILY XXXV.—TORNATELLIDÆ.

Genus *Tornatella.* The shell is external, solid, spiral, many-whorled; outer lip sharp; aperture rounded in front, long, and narrow; columella strongly folded; operculum horny, elliptical. The head is short and notched in front; it has two flattened tentacular lobes, with small sessile eyes

* Greek, *cyclos*, a circle, and *phoreus*, a bearer. † Greek, *stoas*, pillared; *stoma*, mouth.

‡ Greek, *opisthen*, behind; *branchia*, a gills.

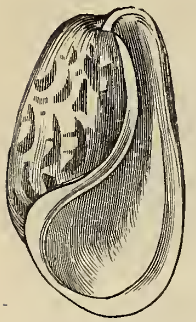
near their bases; the foot is oblong. Sixteen living species have been described. They inhabit deep water in the Red Sea, the Philippines, Japan, &c.

Genus *Ringicula.* Four species are found living in the Mediterranean, India, &c.

Genus *Tornatina.* The shell has a conspicuous spire, fusiform or cylindrical; suture channelled, columella plaited; head of animal broad, rounded in front, with triangular tentacular lobes; eyes at their base; foot truncated in front. *Tornatina* is found on sandy bottoms at a depth of thirty fathoms. Fifteen species occur, very widely distributed over the world.

FAMILY XXXVI.—BULLIDÆ.

The shell is thin, convoluted, cylindrical, or globular; spire concealed, aperture long; lip sharp, without operculum. The shell is more or less internal, being covered by the lobes of the mantle of the animal. The *Bullidæ* are animal feeders; the gizzard is provided with calcareous plates, which assist in the process of digestion.



BULLA OBLONGA.

Genus *Bulla*, the "Bubble-shell." The shell in *Bulla* has no spire; the aperture is as long as the shell, and rounded at the ends; the tentacular lobes form with the head a flattened disc, truncated in front, lobed behind. *Bulla* is found living from low water to thirty fathoms. Fifty widely-distributed species have been described.

In the genus *Scaphander* * the characters are, shell convolute; spire concealed; aperture expanded, oblong; surface spirally striated; animal blind; head oblong; foot broad and short; the lobes of the mantle partially envelop the shell. Five species occur recent, in Britain, Norway, the Mediterranean, &c., living at a depth of fifty fathoms.

Genus *Philine.* The animal is like a Slug; mantle entirely covering the shell; head oblong; blind; foot broad. It is found living in Britain, Norway, the West Indies, &c.

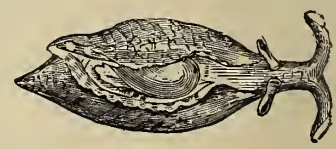
The genus *Doridium* has only a rudimentary membranous shell, covered by the mantle.

The other remaining genus (*Gastropteron*) is shell-less.

FAMILY XXXVII.—APLYSIADÆ.

Genus *Aplysia*, the "Sea-hare," has a long neck; the head has four tentacles, the inner pair ear-like, with the eyes at their bases; the shell is translucent, oblong, rudimentary; it is covered by the mantle. "The Sea-hares live chiefly on seaweed, but also devour animal substances. They inhabit the laminarian zone. When molested they discharge a violet fluid from the edge of the internal surface of the mantle." (Goodsir.) Forty species are found in Britain, Norway, West Indies, &c.

SHELL OF APLYSIA INCA.



APLYSIA INCA.

Genus *Dolabella.* The shell is triangular, hard, with a curved apex. The animal is like *Aplysia.* Twelve species are found living in the Mediterranean, Ceylon, Sandwich Islands, &c.

Genus *Notarcus.* The animal is shell-less. Four species are found in the Mediterranean, Red Sea, and the West Indies.

The genus *Lobiger* has the shell exposed on the middle of the back, covering the plume-like gill.

FAMILY XXXVIII.—PLEUROBRANCHIDÆ.

In the genus *Pleurobranchus* † the shell is quite covered by the mantle; it is large, slightly convex and flexible, nucleus sub-spiral; head with two grooved tentacles, eyes at their bases; foot large, separated from the mantle by a furrow; a single gill is placed on the right side between the mantle and the foot. Twenty species are met with living in Britain, Norway, and the Mediterranean, &c.

Genus *Umbrella.* The "Chinese Umbrella-shell" has a small depressed Limpet-like shell, marked by concentric lines of growth; the animal has a very large foot, deeply notched in front; the tentacles are ear-shaped. Three species are found in the Mediterranean, &c.

The genus *Tylodina*, of which there are three species living, is very like the preceding. It occurs in the Mediterranean, Norway, &c.

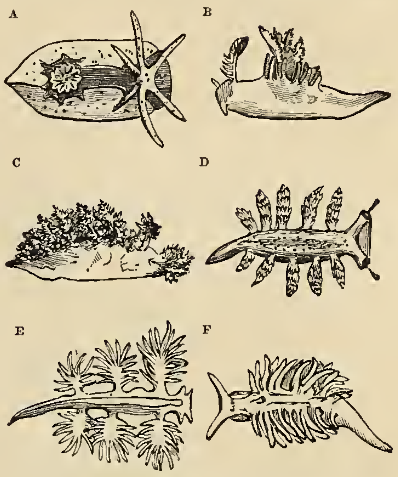
* Greek, *scaphe*, a boat, and *aner*, a man.

† Greek, *pleura*, the side, and *branchia*, the gills.

FAMILY XXXIX.—PHYLLIDIDÆ.

In the genera *Phyllidia* and *Diphyllidia* the animal is shell-less, the internal organs being covered by the mantle; the gills form a series on both sides of the body, between the foot and the mantle. They are found in Britain, Norway, and the Red Sea.

Division b. NUDIBRANCHIATA.—The Sea Slugs are found on all coasts where the bottom is firm or rocky, from between tide-marks to a depth of fifty fathoms. A few species are pelagic, crawling on the stems and fronds of floating seaweed. They have been found in the Icy Sea and in the Sea of Okhotsk, whilst in tropical and southern seas they are abundant. The animal is destitute of a shell, except in the embryo state. The branchiæ are always external on the back and sides.



A, IDALIA; B, MIRANDA; C, DENDRONOTUS; D, DOTO; E, HERMÆA; F, GLAUCUS.

FAMILY XL.—DORIDÆ (SEA-LEMONS).

The gills are plume-like, and placed in a circle in the middle of the back. Genera: *Doris, Goniodoris, Triopa, Ægirus, Thecacera, Polycera, Idalia, Ancula,* and *Ceratosoma.*

FAMILY XLI.—TRITONIADÆ.

The gills in this family are arranged along the sides of the back; the tentacles are retractile into sheaths. Genera: *Tritonia, Scyllæa, Tethys, Bornella, Dendronotus, Doto, Melibœa,* and *Lomanctus.*

FAMILY XLII.—ÆOLIDÆ.

In this family the tentacles have no sheaths and are non-retractile; the gills are placed on the sides. Genera: *Æolis, Glaucus, Fiona, Embletonia, Proctonotus, Antiopa, Hermæa, Alderia.*

FAMILY XLIII.—PHYLLIRHOIDÆ.

These are pelagic footless Sea Slugs, swimming with a fin-like tail. They have two dorsal tentacles and no gills. Genus: *Phyllirhoe.*

FAMILY XLIV.—ELYSIADÆ.

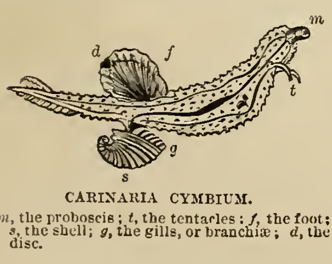
The animal is Slug-like, without distinct mantle or breathing organs; the surface of the body is ciliated. Genera: *Elysia, Acteonia, Cenia, Limapontia.*

ORDER IV.—NUCLEOBRANCHIATA.

This order is so called because the animals contained in it have the respiratory and digestive organs arranged in a sort of nucleus on the posterior part of the back. All the members are pelagic, swimming on the surface of the sea; still, they are entitled to a place in the class. They swim rapidly by vigorous movements of their fin-like tails or by a fan-shaped ventral fin, and they can adhere to objects by a small sucker placed on the margin of the latter.

FAMILY XLV.—FIROLIDÆ.

Genus *Firola.* The animal is fusiform, with a long slender head; fin narrow at the base, having a small sucker; eyes black and distinct. Eight species are known in the Atlantic, Mediterranean, &c.



CARINARIA CYMBIUM.
m, the proboscis; *t*, the tentacles; *f*, the foot; *s*, the shell; *g*, the gills, or branchiæ; *d*, the disc.

Genus *Carinaria.* The body is large and translucent, head cylindrical, tentacles slender, ventral fin rounded, tail laterally compressed; the gills are numerous, and covered beneath by a delicate hyaline. The shell is Limpet-shaped, with a sub-spiral apex. "The Heteropoda are very close to the Gasteropoda, and in most modern works on zoology they are associated with them as a sub-class. They are entirely pelagic, and as it is only under peculiar circumstances that one can stop the ship in mid-ocean and hunt for them, they are little known. One

or two of their shells are met with in collections; one especially, *Carinaria*, a beautiful little glassy boat, which one would take at first for some form of Paper Nautilus. The shell of *Carinaria* gives no idea, however, of the form of the animal which, with one or two allied genera—such as *Pterotrachea* and *Firoloides*, which do not produce shells at all—is sometimes abundant in calm weather on the surface of the warm seas. The shell hangs below the animal, connected with it by a kind of neck, and is merely meant for the protection of some very vital organs, including the heart, the gills, and the liver. The remainder of the animal is ten times the size of the shell, and forms a large sac, usually gelatinous and very transparent, often dotted over with purple pigment spots. The front of the sac is drawn out into a long, singularly-formed snout, and near it there are bright, well-marked eyes, and a pair of feelers. The posterior part of the sac is produced into a fin-like tail. Along the upper middle line of the animal, in the position in which it swims in the water, the part corresponding with the 'foot' in ordinary shell-fish is raised into a high crest-like fin. The bodies of these creatures are large, some of them not less than five or six inches in length, but, like most free-floating animals, they are very soft, formed mainly of 'connective tissue,' with little in it but sea-water. In this way their bulk is greatly increased without materially adding to their weight, and they weigh little more than an equal bulk of sea-water, and require little exertion to float or swim.

"One curious result of this transparency is that we can see through the outer wall, in the most wonderful detail, all the internal arrangements—the nervous centres, with the complicated organs of sense, the heart, with its pulsating chambers, and the blood following its course through the system and through the gills, the alimentary canal, and all its accessory glands. The Heteropoda are probably the most highly-organised group in which such transparency exists.

"The shells of *Carinaria* are rare in the globigerina ooze; but two small spiral shells, belonging to animals of the *Atlanta peronii* and *Oxygyrus keraudrenii*, are sometimes in such numbers as to have a sensible effect in adding to the formation. Although Heteropod shells of the present day are insignificant in size, they played a much more important *rôle* in early times, for there seems little doubt that the great shells of the genera *Euomphalus* and *Bellerophon*, which sometimes go far to make up whole beds of limestone of the Silurian and Carboniferous periods, are to be referred to this group." *

The *Carinariæ* are found in the warmer parts of the Atlantic and Indian Oceans. They feed on Acalephæ and Pteropods. Five species are described.

Genus *Cardiapoda* has a minute cartilaginous shell; animal like *Carinaria;* habitat, the Atlantic Ocean. Five species are known.

FAMILY XLVI.—ATLANTIDÆ.

In the genus *Atlanta* the shell is small and glassy, with a prominent keel; the aperture is narrow and deeply notched. Fifteen species occur in the warmer parts of the Atlantic.

CLASS III.—PTEROPODA.

The *Pteropoda*, or "Wing-shells," are a small group of animals, whose entire life is passed in the open sea, far away from any shelter, save what is afforded by the floating Gulf-weed, and whose organisation is specially adapted to that sphere of existence. In appearance and habits they strikingly resemble the fry of the ordinary Sea Snails, swimming like them by the vigorous flappings of a pair of fins. To the naturalist ashore they are almost unknown, but the voyager on the great ocean meets with them where there is little else to arrest his attention, and marvels at their delicate forms and almost incredible numbers. They swarm in the tropics, and are no less abundant in Arctic seas, where by their myriads the water is discoloured for leagues. (Scoresby.) They are seen swimming on the surface in the heat of the day, as well as in the cool of the evening. Some of the larger kinds have prehensile tentacles, and their mouths are armed with lingual teeth, so that, fragile as they are, they probably feed on still smaller and feebler creatures (*e.g.*, *Entomostraca*). In high latitudes they are the principal food of the whale and of many sea-birds. Their shells are drifted on shore, and they abound in the fine sediment brought up by the dredge from great depths.

* Sir Wyville Thomson's "Voyage of the *Challenger*," Vol. I., p. 121.

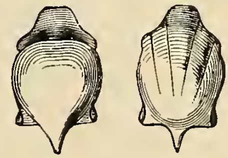
Division a. Thecosomata.—*Animals provided with an External Shell.*

1. Family Hyaleidæ:—Genera *Hyalea; Cleodora; Creseis; Cuvieria; Eurybia; Cymbulia; Tiedemannia.*
2. Family Limacinidæ:—Genera *Limacina; Spirialis; Cheletropis; Macgillivrayia.*

Division b. Gymnosomata.—*Without a Shell.*

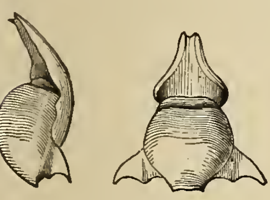
3 Family Cliidæ:—Genera *Clio; Pneumodermon; Pelagia; Cymodocea.*

Professor Sir Wyville Thomson, in his "Voyage of the *Challenger*," writes:—"When dredging off Portugal, at depths beyond five hundred fathoms, in the now well-known 'Globigerina ooze,' that is to say, a greyish calcareous paste, soft on the surface, becoming firmer below, and made up in a great degree of the shells of foraminifera, chiefly of the genera *Globigerina* and *Orbulina*, entire or more or less broken up and disintegrated, along with the foraminiferous shells some other shells of much larger size enter, in varying proportions, into the composition of the ooze, or perhaps may be rather said to be mixed with it. These are principally shells of Pteropods, with a few of those of Heteropods and of pelagic Gasteropods." . . . . "Most of these animals live on the bottom of the sea, as their organisation demands. One or two only of the shell-making genera are pelagic."



HYALEA GIBBOSA.

Of the genus *Clio* we "have in the Northern Polar Seas the *Clio borealis*, which is there found in such plenty as to constitute a considerable portion of the Greenland Whale's food. Passing over the intermediate oceans, that genus is, according to S. P. Woodward, represented in the Antarctic Ocean by some few species, but, according to H. and A. Adams, by only one, the *Clio australis.*



HYALEA LONGIROSTRIS.

"The Pteropoda are farther removed than the Heteropoda are from the typical Gasteropoda, and are much simpler in their structure. The head is not so markedly separated from the body, and the organs of sense are rudimentary. The body is conical and sometimes spiral, and is very usually contained in a delicate shell, sometimes spiral in form, more frequently conical or tubular, or like an ornamental flower-glass, or like a watch-pocket. The foot is modified into two wing-like appendages, one on either side of the mouth. These are frequently brightly coloured when the animal is living, and different parts of the body show iridescent blues and greens. Multitudes of these little things may now and then be seen on the surface of the water, fluttering with their wings and glittering in the sunshine, to be compared with nothing more aptly than with a congregation of the more dressy of the Bombyx Moths, as one sometimes comes upon them on a sunny morning, just after a family of them have escaped from their chrysalises.

"The Pteropods are much smaller than the larger forms among the Heteropods; the largest of the present day are not more than about an inch in length, though antediluvian species of the genus *Conularia* and its allies sometimes reach a length of nearly two feet. They make up for their small size, however, by their numbers. Everywhere in the high seas they absolutely swarm. They are not always to be taken in the towing-net, as they seem to have a habit in the heat of the day, and when there is any wind, of swimming a little way below the surface, but in a fine calm evening, no matter where, a haul of the towing-net can scarcely be made without catching many of them.

CLEODORA CUSPIDATA.

C. LANCEOLATA.

C. COMPRESSA.

"The most widely distributed species in the Atlantic seems to be *Diacria trispinosa*, with a little pocket-like shell of some weight and strength, shaded purple and white. Several species of *Cavolina* are

abundant, the largest *C. tridentata.* *Clio cuspidata,* with a fretted shell, whose ornament reminds one of some of the fossil genera, is perhaps the species most frequently seen on the surface, and the one which shows the iridescent colouring with the greatest brilliancy. The several species of *Styliola,* much smaller than the others, are much more numerous, and sometimes throng the towing-net with their glassy needles. *Styliola subulata, S. acicula,* and *S. virgula* are in immense abundance, and very generally distributed. Some of these species sometimes reach the coast of Britain, but an indraught of northern water, which includes the British Islands in a fork, keeps out these oceanic things from our shores. If the British naturalist, to whom these things are usually unknown in a living state, will only push his towing-net work by a tug steamer, or his own or a friend's yacht, forty or fifty miles from the West Coast of Scotland or Ireland, he will get beyond the Arctic water, and will wonder, as I did, at the new animal world, in the shape of *Pteropoda, Heteropoda, Siphonophora,* and, above all, *Polycystina* and *Acanthometrina,* in all their wonderful varieties of form and sculpture, which will suddenly burst upon him.

"The *Pteropoda* extend far to the northward; one, *Limacina helicina,* with a delicate but very elegant spiral shell, and another, *Clione borealis,* which belongs to the shell-less subdivision, are frequently seen by Arctic voyagers in such numbers that they actually colour the surface of the sea in patches of many square miles in extent, and they are said to form a considerable item in the food of the Greenland Whale, which strains them out of the water as it passes through his mouth with his whalebone sieve. I have dwelt on this little group because their history is not very familiar, and because, small as they are, they play by no means an unimportant part in some of the recent geological processes of reconstruction." *

CHAPTER IV.

THE CONCHIFERA.

Class IV., CONCHIFERA—Bivalve Shells—Their Sedentary or Burrowing Habits—Structure of Bivalve Shells—Anatomy of Animal—Muscles, Mantle, Gills, &c.—Family 1. OSTREIDÆ—Oysters—Their Economic Value—Frank Buckland on the Oyster—The "Points" of an Oyster—Mode of Cultivation—The Young Oysters—Their Enemies—Their Sensitiveness to Cold—Ancient Shell Relics—2. ANOMIADÆ—3. PECTINIDÆ—Scallop Shells—The St. James's Shell—The *Spondylus,* or Thorny Oyster—Vivacity of Young Pecten—Value of Bivalve Shells—4. AVICULIDÆ—Pearl Oysters—Use of Shells—Value of Pearls—Pearl-fishery, Ceylon—The Divers—THE GREAT PINNA—5. MYTILIDÆ—Mussels—A Bridge Preserved by Mussels from Destruction—Boring Shells, Lithodomi—6. ARCADÆ—7. TRIGONIADÆ—Trigonias—8. UNIONIDÆ—River Mussels—Pearl Mussels—9. CHAMIDÆ—10. TRIDACNIDÆ—Giant Clams—11. CARDIADÆ—12. LUCINIDÆ—13. CYCLADIDÆ—14. ASTARTIDÆ—15. CYPRINIDÆ—16. VENERIDÆ—17. MACTRIDÆ—18. TELLINIDÆ—19. SOLENIDÆ—"Razor-shells"—20. MYACIDÆ—21. ANATINIDÆ—22. GASTROCHÆNIDÆ—Stone-borers—23. PHOLADIDÆ—Wood-borers—The Ship-worm.

CLASS IV.—CONCHIFERA.†

WE have already glanced at three of the great subdivisions of the Molluscan kingdom—namely, the Cuttle-fishes (Cephalopoda), the Snails (Gasteropoda), and the Pteropods. Let us now take a survey of a fourth group, the *Conchifera,* or "shell-bearing" Mollusca, better known as bivalves, from the fact that the majority are enclosed within a pair of shells united by a hinge, of which the Oyster, Mussel, Cockle, and Scallop are familiar examples. They are never found living on the land, as Snails and Slugs are able to do; and although, owing to their closely-fitting shells, the Dreissena, the Oyster and Mussel, and the fresh-water Cyclas are able to survive exposure for some time, yet as a whole the bivalves are all aquatic, and, with a few exceptions, are all inhabitants of the sea. They occur on the shores of every land in all climates, and are met with from low water-mark to a depth of many hundred fathoms.

* Sir Wyville Thomson's "Voyage of H.M.S. *Challenger,*" Vol. I., p. 123.
† Latin, *concha,* a shell, and *fero,* I bear.

Most bivalves are sedentary in their habits, living in an erect position, either exposed or buried in the sea-bottom, resting on the edges of their shells, which are usually of equal size.

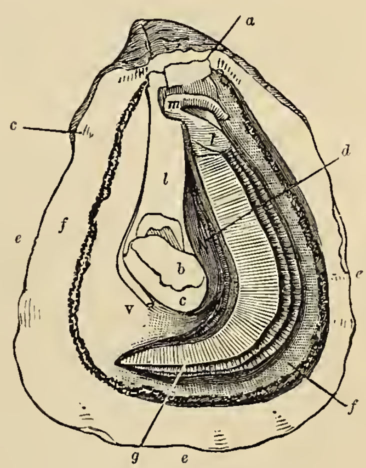
The burrowing forms have a stout muscular foot, with which they dig for themselves a cavity in the sand or mud, leaving only one end of their shell exposed to admit a current of water to the respiratory tube or opening, which also conveys to the animal within a constant supply of particles of food.

There is a tendency observable in bivalve shells, as well as in univalves, to grow in a spiral direction. This is especially well seen in *Isocardia*, whose separate valves resemble two spiral univalves—one right-handed, the other left-handed, with small spires and large apertures. In this shell, as in the common Cockle, one valve is placed on each side of the shell-fish, which is usually symmetrical, and lives in a vertical position as regards the plane of its valves.

To this there are exceptions: as, for example, the Oyster and Scallop, which (like Turbots and Soles among fishes) lie, the former on its left side and the latter on its right side, and fatten at their ease. The shells too are unequal, the deep valve in both cases being the lower shell, and the flat valve the upper.

The valves of the Cockle are united by an elastic ligament, and articulated by projecting teeth, which form a very complete hinge. It is obvious that the valves of a shell cannot grow so freely along the hinge as on the rest of the margin, but it may shoot out to great length, as in the "Razor-shell" (*Solen*), or in three directions, as in the "Hammer-oyster" (*Malleus*), while in the "Heart-cockle" each valve takes a spiral. There are some fossil shells, called *Diceras*, in which the two valves resemble horns, and others called *Requienia*, with one valve produced into a horn. In *Chama* the umbones are also spiral.

In many bivalves the beaks are turned forwards towards the head of the animal. But the Oyster is again an exception in this respect, and if among the exotic or fossil species you find some with spiral growth, the spiral is turned backwards; indeed, the number of exceptions is so great that one fears to make any general assertion. *Anomia*, when it grows inside shells, may have its umbo a little removed from the margin, and the fossil genera *Hippurites* exhibit every condition between a marginal ligament and a spiral beak, like *Chama*, and a patelliform valve, with a ligament wholly internal, and a central umbo.



ANATOMY OF A COMMON OYSTER.*

The shell, considered as a defence, is most complete in those bivalves like the Oyster, which shut up close, and in those univalves which have an operculum, or door, to their houses.

Many bivalves gape a little at the sides (or ends), where the foot and the respiratory tubes are accustomed to be pushed out; whilst *Anomia* has a hole or notch in the right valve, through which a byssal plug passes, by which the animal is attached to foreign bodies.

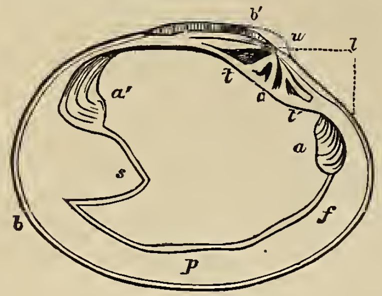
Others bore into more or less hard substances, as wood, clay, chalk, coral, limestone, and sandstone, and many of these boring Mollusca become so remarkably changed and modified in appearance, owing to the life they lead, that, like *Magilus*, already described, we can hardly recognise them as bivalve shells at all.

If we examine the inside of the empty valve of an Oyster, a Pecten, or a Spondylus shell we shall readily detect a single circular scar a little to one side of the valve. This is the point of attachment for the great shell-muscle. If we look at the valve of a *Cytherea*, or any

* *e, e*, the edge of the valve along which (when living) the mantle is attached to the shell; *b* and *c*, adductor muscle; *b*, a portion which separates easily from the shell, *c*, part firmly attached, and which has been cut through; *d*, a convex broad arc on mantle, indicating the part where the gills are attached to it, and forming the outer wall of the dorsal water-chamber into which the gills open; *e*, the true outline of the mantle, the mantle being represented in its shrunk condition, as seen upon opening the oyster; *f'*, silvery muscular lines on the mantle, much branched; *f*, fringed edge—the edge of the mantle is split in its own planes about $\frac{1}{16}$ of an inch, and the space between the two edges is fringed with several rows of minute short tentacles, between which is a dusky pigment; *g*, the gills, or branchiæ; *l*, the liver; *t*, the labial tentacles; *m*, the mouth; *a*, the hinge-line; *v*, the vent.

other shell of that group, we shall observe two of these scars, one on either side (*a á*,). This has led to the former being called *Monomyaria* * (having only one shell-muscle); the others *Dimyaria*† (having two shell-muscles).

These muscles are also called adductors, their functions being to close the valves of the shell and hold them tightly together. We may also notice in the valve of the Monomyarian a simple unbroken line (*p*) just within the margin of the shell. This is the line of attachment of the animal's mantle to its shell, and is called the pallial‡ border, because the mantle is the membrane which envelops all the Mollusca, and is that structure which secretes the shell. This line is simple in the Oyster and its allies, which have no siphonal tubes; and indented in shells like *Cytherea* (*s*), which are provided with siphons which could be drawn within the valves of the shell by muscles specially provided for that duty; this fold or notch is called "the pallial sinus." The soft parts of an ordinary bivalve shell are shown at p. 249, consisting of the mantle (*m*); the branchiæ, or gills (*b r*); the incurrent and excurrent siphons (whose position is marked by two arrows); the foot (*f*), which enables many of the bivalves to burrow, and which in some species secretes the threads of the byssus, by which they can moor themselves to rocks or floating objects. Then there are the shell-muscles, and the muscles of the foot and of the siphons, and the muscular fibres of the mantle, the stomach, liver, heart, and intestine, The water passing in by the incurrent siphon or tube is conveyed to the gills, through the folds of which it passes, the particles of food, whether living or dead, being guided by the labial tentacles, or lip-feelers, to the mouth, the excurrent orifice serving, as in the Tunicata, to carry away what is done with.



ANATOMY OF CYTHEREA.

ū, is the umbo of the valve; *b'*, the hinge cartilage; *l*, the "tunule"; *b*, the posterior of the border of the valve; *f*, the front or anterior border; *a*, *a*, the scars where the two great adductor musclesof the animal are attached; *t*, *t'*, indicate the hinge-teeth.

Division a. ASIPHONIDA.§—In this section the lobes of the mantle are free, or only united at the point which separates the branchial chamber from the ex-current chamber. The animal has no respiratory siphons.

FAMILY I.—OSTREIDÆ.

The animals of this family are marine; the mantle is free, only slightly adhering to the edges of the shell. The shell is closed by a single muscle; valves unequal, adhering by one valve.

Genus *Ostrea.* The shell of the Oyster is irregular; the upper valve flat, the lower convex often plaited or lamellated; pearly within; ligament triangular; margin of mantle finely fringed; gills almost equal, united behind to one another and to the mantle, and completely enclosing the branchial sac. There is an intimate connection between the mantle of the mollusc and its shell. The Oyster, as we see it on the supper-table, is much smaller than its shell, and adheres only by its glistening shell-muscle; but when alive, its mantle extends to the very edge of the valves, lining the whole interior, and having a slight adhesion, especially at the edge of the valves, which is speedily ruptured, however, when the poor animal is forcibly invaded by the fishmonger's knife. Oysters are found in the temperate and tropical seas all over the world. Nearly 100 species have been described.

No shell-fish has, probably, endured more severe havoc from mankind than the common Oyster, for it is only in comparatively late years that it received the protection of Mr. Frank Buckland, and became a subject for Parliamentary Committees to discuss and Government to legislate for.

The shores of Denmark and her islands are marked by vast shell-mounds (kjökken-möddings), indicating the primitive taste for *Ostrea edulis.* No doubt vast strata of oyster-shells must exist beneath London, when we consider that from 20,000 to 30,000 bushels of "Natives," and 100,000 bushels of "Sea Oysters" were (thirty years ago) annually supplied to the London market. And although, owing to the increased price of this mollusc, a considerable falling off has occurred of late in the supply of "Natives," the latter have, no doubt, been brought in larger quantities, as well as foreign Oysters, to meet the demand.

"Sea Oysters" (*i.e.*, Oysters naturally grown) obtain their majority in four years, but "Natives"

* Greek, *monos*, one; and *mus*, a muscle.
† *dis*, two; and *mus*.
‡ From Latin, *pallium*, a cloak or mantle.
§ Greek, *a*, without, *siphon*, a tube.

(*i.e.*, Oysters artificially cultivated) do not reach their full growth in less than five or seven years. It was the bringing of immature Oysters to market which, to a great extent, produced the subsequent scarcity of this article of food. Many other species of Oysters are eaten in India, China, Australia, &c.

Frank Buckland writes:*—"There are almost as many kinds of Oysters as there are kinds of dogs; no two Oysters are exactly alike, but those which come from the same locality bear a general resemblance to each other, so that any one accustomed to handle and criticise Oysters can tell pretty well where they were reared. Taking the English coast round, there are not many localities suitable for Oyster-farming. The reason of this is that where sand is Oysters cannot possibly exist; the grains of sand get into the hinge of the Oyster, and, like a stone in the hinge of a door, they prevent the opening and shutting of the valves of its shell. The sand then smothers the Oyster, his valves gape, and he dies. For this reason there are no Oysters in the great estuary of the Solway, or in Morecambe Bay (the head-quarters for Cockles), the estuary of the Flintshire Dee, the vast expanse of Cardigan Bay, and the greater part of the estuary of the Severn. Several times has the idea been started to use for an Oyster-farm the great plain of the Maplin Sands at the mouth of the Thames, but Oysters cannot possibly thrive there; it is all sand. From the Land's End to the North Foreland we begin to find Oysters in the various estuaries and land-locked bays: for example, Falmouth, Plymouth, Poole Harbour, the Solent, Portsmouth, Hayling, Havant, &c.; also in the Isle of Wight, in the Medina River, Brading, &c. On the north-east coast there are but few Oysters, Boston Deeps and Holy Island being excepted.

"Oysters may be divided into natives and deep-sea, and between these there are several varieties. The deep-sea Oysters are as different in form and fashion from the natives as a Clydesdale cart-horse is from a thoroughbred race-horse. Like horses, Oysters have their points. The points of an Oyster are—first, the shape, which to be perfect should resemble very much the petal of a rose-leaf. Next, the thickness of the shell; a first-class thoroughbred native should have a shell of the tenuity of a thin china or a Japanese tea-cup. It should also have an almost metallic ring, and a peculiar opalescent lustre on the inner side; the hollow for the animal of the Oyster should be as much like an egg-cup as possible. Lastly, the flesh itself should be white and firm, and nut-like in taste. It is by taking the average proportion of meat to shell that Oysters must be critically judged. The Oysters at the head of the list are, of course, 'natives;' the proportion of a well-fed native is one-fourth meat. The nearest approach to natives both in beauty and fatness are the Oysters from Milford, in South Wales. The deep-sea Oysters, such as the white-faced things dredged up in the Channel between England and France, and stored at Shoreham, near Brighton, are one-tenth meat; while the very worst are some Frenchmen, which are as thin and meagre as French pigs. I have weighed half-a-dozen natives; the meat contained in these weighed two ounces; the value, therefore, of Oyster meat—at 3s. 6d. per dozen—is fourteen shillings per pound, just the cost of a 14 lb. leg of mutton.

"It is not to be supposed for a minute that the high-classed aristocratic native has reached the position of the King of Oysters without a great deal of human labour and intelligence having been spent during many generations of dredgermen upon his education. The mouth of the Thames, within a line drawn from about Walton on the north to Margate on the south, may be considered as the home of the true British native. This kind of Oyster seems to thrive only upon London clay. So far as my experience goes, I have come to the conclusion that a fatting place for Oysters is seldom also a breeding place; the fatting grounds must always be situated in water, with which a certain amount of river water is mixed with sea water. Whitstable is *par excellence* the best fatting ground in the world, because the food of the Oyster (a subject which has hitherto not been sufficiently investigated) is there present in the greatest abundance, and also because at Whitstable the Oysters are continually being worked by the dredge. The food of the Oyster consists of very minute organisms (such as Infusoria, Rhizopoda, and microscopic larval forms of Cœlenterata).

* Since this article was in course of preparation this amiable and accomplished naturalist has passed away. In many a far-off village upon our coast, and on many a Salmon-stream, his name will long be cherished as a household word. Few men had more friends. Enemies he had none, save those "rascals," as he styled them, "who wouldn't let a poor Salmon have a chance to come up stream to spawn." He was the true friend of animals of all kinds, and all animals loved Frank Buckland.

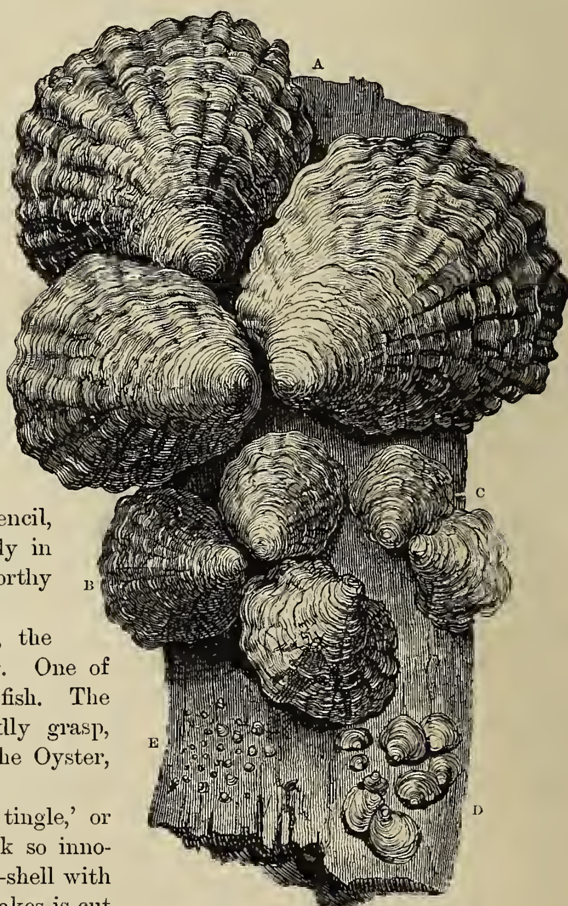
"The Oyster's mouth is situated between the delicate folds of what is ordinarily called the beard, *i.e.*, the breathing organs, and by following down the course of the gullet the stomach can easily be found, embedded in the thick part of the body of the Oyster, which is really the liver. It is in the month of June that Oysters mostly spawn; the 'spat,' as it is called, resembles very fine slate-pencil dust, and the number of spats in one Oyster I find from experiment varies from 829,000 to 276,000 individuals. One fine hot day the mother Oyster opens her shell, and the young ones escape from it in a cloud, which may be compared to a puff of steam from a railway engine on a still morning. Each little Oyster is provided at its birth with swimming organs, composed of delicate cilia, and by means of these the little rascal begins to play about the moment he leaves his mother's shell. Unless born in an enclosed water paddock, he swims away with the tide to and fro until he dies, or finds a rest suitable for him. Oysters, in fact, may be said to 'swarm' like bees, and many a bed has been discovered the origin of which is attributable to a swarm of Oysters having alighted on the spot.

YOUNG OYSTERS FURNISHED WITH LOCOMOTIVE ORGANS.

"The little Oysters, the size of a fourpenny-piece to a sixpence, are called 'brood,' the larger are called 'half ware,' and these are sold by what is called a 'wash,' which contains twenty-one quarters and a pint. These young Oysters increase in size by adding to the margin of their shell a very delicate layer of a horn-like elastic substance, at first almost as thin as gold-beater's skin, but which eventually hardens into shell: this is called the 'growth.' In a well-marked native the rings of annual growth are plainly perceptible. If the shell be well washed the growth will take the markings of a pencil, and it will be found that the Oyster is generally in his fifth or sixth year before he is thought worthy of an introduction to London society.

"Being of a very delicate tender nature, the Oyster has a great many difficulties to encounter. One of his worst enemies is the 'five finger,' or Star-fish. The 'five finger' entwines the Oyster in his deadly grasp, and by protruding his elastic stomach eats up the Oyster, leaving the empty shells, known as 'clocks.'

"The next worst enemy is the 'Whelk tingle,' or 'Dog Whelk.' These rascals, although they look so innocent, have the power of boring into the Oyster-shell with their rasp-like tongue. The hole this creature makes is cut very clean, as if bored by a jeweller's diamond, and they often destroy hundreds of pounds' worth of property. He who would invent a trap to catch these 'Dog Whelks' would indeed be a benefactor to Oyster fishery proprietors.



GROUP OF OYSTERS OF DIFFERENT AGES ATTACHED TO A BLOCK OF WOOD.

A, Oyster of Twelve to Fifteen Months; B, of Five to Six Months; C, of Three to Four Months; D, of One to Two Months; E, Twenty Days after Birth.

"The Oyster is most intolerant of cold and very tolerant of heat. There are no Oysters in the Arctic seas; in all tropical seas they abound, but are not always edible. In the winter season owners of Oyster layings watch the weather most carefully, shifting Oysters from the fore-shore into deep

water, for if the frost catches them it nips them up. Particularly dangerous are also the floods from melted snow, and as fresh river water alone is sufficient to kill Oysters, much more so are they in danger if the temperature is reduced by melting ice or snow. Valuable layings of Oysters have thus been frequently destroyed by winter floods too powerful for the flowing tide to dilute. This great abhorrence of cold on the part of high-bred Oysters, such as natives, is, in my opinion, one of the principal causes of their high price. Of late years the summers have been very cold, and although the water may perchance have attained to a certain amount of heat, yet the cold nights knock all the warmth out of it again. Above all, it is necessary for a fall of spat that the temperature should not jump up and down, but be as equable as possible. The young Oysters cannot help being born, and when born they must take their chance of the weather. If it is cold, they die; if it is warm, and they are lucky enough to find cradles in the form of 'culch' suited for them, they hold on as tight as barnacles, and have a chance of living."

Many British cists and cairns have disclosed relics in the form of shell necklaces and bracelets made of the Oyster, Limpet, and Cockle-shells, the contents of which supplied an important source of food. For not only in the ancient kitchen middens of Northern Europe, but mingling with more ancient cave deposits, as in Kent's Cavern, lay heaps of the shells of such edible Molluscs, the refuse of the repasts of the old cave-men, which show one resource on which they depended for subsistence. America, too, had its ancient shell and refuse heaps, as at Cannon's Point, St. Simon's Island, Georgia, where vast mounds of Oyster and Mussel shells, intermingled here and there with a *Modiola* or *Helix*, and with flint arrow-heads, stone axes, and fragments of pottery, cover an area of not less than ten acres. They also abound upon all the sea islands of the Southern States, and in many cases constitute regular sepulchral mounds or shell cairns. One of these singular cairns on Halling's Island, in the Savannah River, more than two hundred miles from its mouth, is an elliptical mound, measuring nearly three hundred feet in length, and enclosing human skeletons, &c. On the islands, and along the coasts of Georgia and Florida, the inexhaustible supplies of Oysters, Conches, and Clams furnish abundant food. Around all the Indian villages these shells may be observed accumulated in vast heaps; and even now at places they show the circular hollow where the native hut once stood.

FAMILY II.—ANOMIADÆ.

Genus *Anomia*.* The shells of *Anomia* are very variable in form, being nearly always attached to the surface of shells of other Mollusca, the pattern of whose markings they mould themselves to. The shell is translucent, nearly round, and attached by a plug passing through a hole or notch in the right valve; the lower valve is concave, the upper valve convex, and the muscular impression single. Twenty species are found living. They are not edible. They occur from low water to 100 fathoms.

Genus *Placuna*,† "Window-shell." The valves of *Placuna* are nearly round and almost flat: the hinge cartilage is fixed by two ridges on the right valve, with corresponding grooves on the left; the muscular impression is double; there are one large round scar, and a smaller, crescent-shaped, in front; the shell is pearly and translucent. Four species are living in India, Australia, China, and Ceylon.

"The Tamblegam Lake produces in singular perfection the thin transparent Oyster (*Placuna placenta*), whose clear white shells are used in China and elsewhere as a substitute for window-glass. They are also collected annually for the sake of the diminutive pearls contained in them. These are exported to the coast of India, to be calcined for lime, which the luxurious affect to chew with their betel. These pearls are also burned in the mouths of the dead. So prolific are the Mollusca of the *Placuna*, that the quantity of shells taken by the licensed renter in the three years prior to 1858 could not have been less than eighteen millions. They delight in brackish water; and on more than one occasion an excess of either salt water or fresh has proved fatal to great numbers of them."‡

The pearl fishery of Lake Tamblegam, near Trincomalee, clears £300 a year; individual pearls of *P. placenta* do not exceed 6s. in value.

* Greek, *anomios*, unequal.

† Greek, *plakous*, a thin cake.

‡ Sir J. Emerson Tennent: "Ceylon," vol. ii., p. 492.

FAMILY III.—PECTINIDÆ.

Genus *Pecten.** The shell of the "Scallop" is fan-shaped, or nearly circular, and has the following characters—the right valve deep, the left valve flat, usually ornamented with radiating ribs; hinge-line eared; valves united by a narrow ligament; hinge cartilage internal; the mantle quite open, its border double, and finely fringed with a row of round black eyes at its edge. The Scallop ranges from three to forty fathoms. Its body is bright orange or scarlet. The shell is used for "scalloping Oysters." The Pectens are characterised by the brilliant red and yellow colouring of their shells, few groups exceeding them in elegance of form and ornamentation.

Pecten maximus, commonly known as "Scallops" in the London market, "Queens" at Brighton, and "Frills" on the coasts of Dorset and Devonshire, are now almost as much eaten as Oysters; but they require to be cooked first.

An allied species has received the name of "St. James's shell" (*Pecten Jacobœus*). It was worn by pilgrims to the Holy Land. The fossil Pectens found in the sub-Apennine formation of Italy were supposed by early writers to have been dropped by these devout persons on the road. Parnell says of the hermit:—

> "He quits his cell; the pilgrim staff he bore,
> And fixed the *scallop* in his hat before."

The aged Pectens certainly are sedentary in their habits, as is testified by the mass of *Bryozoa*, *Serpulæ*, *Alcyonium*, and *Balani* attached to their upper flat valve. They do not, however, fix themselves, like the Oysters, by the deep valve, but some species are moored by a byssus to stones or the stems of the *Laminariæ*.

The young Pectens swim freely by rapidly closing and opening their valves. The writer, when dredging with Mr. MacAndrew, off Coruña, has seen *Pecten opercularis*, two inches in diameter, swim rapidly out of the dredge as it was being hauled up alongside the boat.

Genus *Lima.*† In this genus the valves are equal and obliquely oval; the front side is straight and gaping, the posterior is rounded and closed; the umbones of the valves are separated; the hinge-line is eared; the valves are smooth or radiately ribbed; the muscular impression is large, lateral double; the shell always white.

"The Limas are either free or spin a byssus; some make an artificial burrow when adult, by spinning together sand or coral fragments and shells; but the habit is not constant." (Forbes.) "*L. hians* is pale or deep crimson, with an orange mantle. When taken out of its nests it is one of the most beautiful marine animals to look upon. It swims with great vigour, like the Scallop, by opening and closing its valves, so that it is impelled onwards and upwards in a succession of jumps." (Landsborough.)

Twenty species are found living at a depth from one to one hundred and fifty fathoms in Norway, Britain, India, and Australia.

Genus *Spondylus.* The Thorny Oyster has an irregular shell, with divergent ribs, terminating in foliaceous spines. It is found attached to foreign bodies by the right valve. The umbones of the shell are wide apart and eared, the lower valve has a triangular area to the hinge, and two curved teeth in each valve; the animal is like that of *Pecten.* The Spondyli inhabit coral-reefs, being attached to the branches of the growing coral. Seventy species are known living in the tropics.

A structure analogous to the chambered shell of the Cephalopod occurs in the Thorny Oyster, or *Spondylus.* In aged specimens the shell, instead of increasing in size, becomes thicker in its interior by the addition of inner layers of shell, which are distinct from the outer and from each other. The cavities thus formed are found to contain water, which, however, evaporates after the specimens have been placed in a dry situation for a long period; but the water is again absorbed by immersing the specimens for a sufficient number of hours. This reduction of the inner space appears to be effected in order to counteract the continued increment of the shell (by deposits of new shell-matter along its margin from the border of the mantle) at a greater rate than is required for the accommodation of the soft parts of the animal.

The tubes of *Vermetus* and *Magilus*, and the apices of *Triton*, *Turritella*, and *Euomphalus* become either partitioned off or filled up solid in the continued growth of the animal.

* Latin, *pecten*, a comb.

† Latin, *lima*, a file.

Few of the bivalves have been esteemed "fancy" shells or commanded high prices, but some of the *Chamas* and *Spondyli* are very beautiful, and might well distract a Dutch or French collector. Sowerby valued *Spondylus regius*, in the Tankerville collection, at £25, the best *Chama* at £3 3s., and *Isocardia* at £8 8s. (!); *Ætheria elliptica* at £21 (!); and the *Lucina childreni*, now in the British Museum, at £10 10s., because it had the hinge reversed. Mr. Norris gave £20 for a *Mülleria*, an extraordinary shell to the conchologist (although most unattractive to the eye), of which the late M. D'Orbigny sent several specimens to the British Museum in exchange for a fossil *Pentacrinus*.

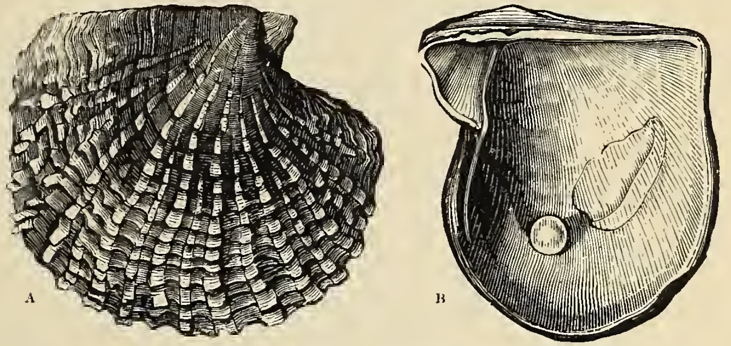
The genus *Plicatula* has an irregular shell, with plicated valves, and is fixed to some foreign body by the beak of the right valve. The *Plicatulæ* are tropical shells. Ten species occur in the East and West Indies, the Philippines, &c.

FAMILY IV.—AVICULIDÆ.

The shell is very oblique and the valves unequal; it is attached by a byssus; they are pearly within, the outer layer is cellular, the lobes of the mantle are fringed at the margin; it has two gills on each side. The Pearl Oysters, or "Wing-shells," as they are called, are mostly tropical.

Genus *Avicula*. The shell is very unequal; there is a fold for the byssus in the right valve, beneath the ear of the shell; there are one or two small teeth in the hinge; the valves are obliquely oval. Twenty-five species occur living in about twenty-five fathoms water in Britain, the Mediterranean, India, &c.

Genus *Meleagrina*. The valves of the Pearl Oyster are flattish and nearly equal in size, the gills are equal and crescent-shaped, the foot finger-like and grooved. *Meleagrina* is less oblique than the other *Aviculæ*. They are found living in Madagascar, Ceylon, Swan River, &c.



MELEAGRINA MARGARITIFERA—A, OUTSIDE; B, INSIDE OF SHELL.

The shells of the "Pearl Oyster" afford the substance known as "mother-o'-pearl," so largely employed in the manufacture of buttons and for *papier-mâché* inlaid-work, &c.

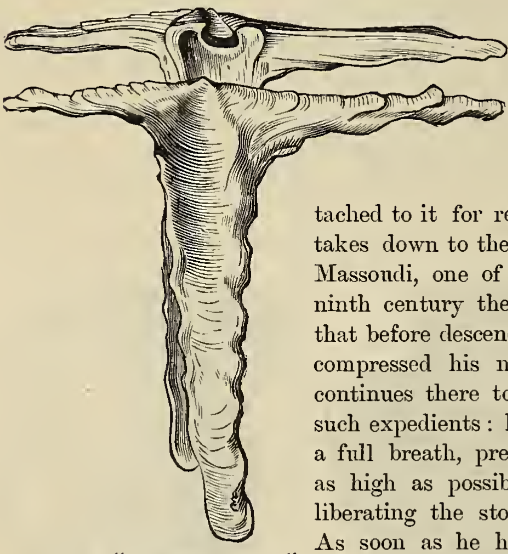
Prof. T. C. Archer mentions that there are three principal kinds of these mother-o'-pearl shells brought to market at Manilla (which is the *depôt* for the Pearl Oyster trade). The valves realise from £2 to £4 per hundredweight.

One kind is known as the silver-lipped Pearl Oyster, from the Society Islands; another the black-lipped variety, from Manilla; the third, from Panama, is smaller than the others. About 250 tons of these shells are annually imported into Liverpool alone. They also yield the "oriental" pearls of commerce. The principal pearl fisheries are in the Persian Gulf and Ceylon. Pearls are produced by many bivalves, but by none in greater perfection than by the *Meleagrina margaritifera*. They are caused by particles of sand or other foreign substance finding its way into the cavity of the valves, and getting between the animal and its shell; the irritation causes a deposit of nacre, forming a projection on the interior, generally more brilliant than the rest of the shell. Completely spherical pearls can only be found loose in the muscles or other soft parts of the animal. The Chinese obtain them artificially by introducing into the living *Hyria* foreign substances, such as pieces of mother-o'-pearl fixed to wires, which thus become coated with a more brilliant material. Similar prominences and concretions—pearls which are not pearly—are formed inside porcellanous shells. These are as variable in colour as the surface on which they are formed. They are pink in *Turbinella* and *Strombus*; white in *Ostrea*; white or glossy, purple or black, in *Mytilus*; rose-coloured and translucent in *Pinna*.

The pearl-fisheries of the Persian Gulf and Ceylon give employment annually to several hundred boats and many thousand men. The entire amount of revenue derived from the pearl-fisheries of

Ceylon in nine years (from 1828 to 1837), according to Mr. James Steuart, the Inspector of Pearl Banks, was £227,131, but it has since decreased very considerably. Mr. Hope possessed a pearl measuring two inches in length and four in circumference, and weighing 1,800 grains. This is said to be the largest pearl known. A very fine pearl *bouton* was sold in London in 1860 for £2,000: it measured about five-eighths of an inch. Good pearls of two grains weight are common, and fetch about 7s. 6d. each; pearls weighing five grains are worth £2 each; pearls of ten grains weight sell for £7 and £8 apiece. But the best market for pearls is in India itself, where they are more highly esteemed than in Europe, and realise far higher values.

Sir Emerson Tennent gives the following interesting account of diving for Pearl Oysters on the coast of Ceylon:—"On my arrival at Aripo, the pearl-divers, under the orders of their Adapanaar, put to sea, and commenced the examination of the banks. The persons engaged in this calling are chiefly Tamils and Moors, who are trained for the service by diving for chanks. The pieces of apparatus employed to assist the diver in his operations are exceedingly simple in their character: they consist merely of a stone, about thirty pounds weight (to accelerate the rapidity of his descent), which is suspended over the side of the boat, with a loop attached to it for receiving the foot; and of a network basket, which he takes down to the bottom and fills with the Oysters as he collects them. Massoudi, one of the earliest Arabian geographers, describing in the ninth century the habits of the pearl-divers in the Persian Gulf, says that before descending each filled his ears with cotton steeped in oil, and compressed his nostrils by a piece of tortoiseshell. This practice continues there to the present day; but the diver of Ceylon rejects all such expedients: he inserts his foot in the 'sinking stone' and inhales a full breath, presses his nostrils with his left hand, raises his body as high as possible above water, to give force to his descent, and, liberating the stone from its fastenings, he sinks below the surface. As soon as he has reached the bottom the stone is drawn up, and the diver, throwing himself on his face, commences with alacrity to fill his basket with Oysters. This, on a concerted signal, is hauled up rapidly to the surface, the diver assisting his own ascent by springing on the rope as it rises."



THE "HAMMER OYSTER," MALLEUS ALBA.

"Improbable tales have been told of the capacity which these men acquire of remaining for prolonged periods under water. The divers who attended on this occasion were among the most expert on the coast, yet not one of them was able to complete a full minute below. Captain Steuart, who for many years filled the office of Inspector of the Pearl Banks, assured me that he had never known a diver to continue at the bottom longer than eighty-seven seconds, nor to attain a greater depth than thirteen fathoms; and on ordinary occasions they seldom exceeded fifty-five seconds in nine fathoms water.

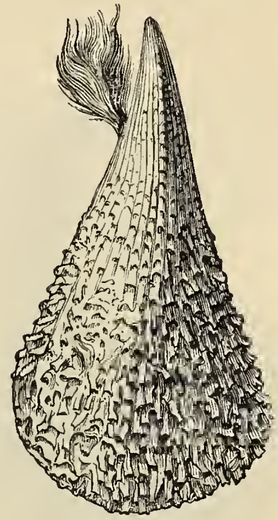
"The only precaution to which the Ceylon diver devotedly resorts is the mystic ceremony of the shark-charmer, whose exorcism is an indispensable preliminary to every fishery. His power is believed to be hereditary; nor is it supposed that the value of his incantations is at all dependent upon the religion of the operator, for the present head of the family happens to be a Roman Catholic. At the time of our visit this mysterious functionary was ill and unable to attend; but he sent an accredited substitute, who assured me that although he himself was ignorant of the grand and mystic secret, the fact of his presence as a representative of the higher authority would be recognised and respected by the Sharks." ("Ceylon," Vol. II., p. 563.)

Genus *Perna*. These shells, like the *Aviculæ*, vary greatly in form, some being very oblique and inequivalved, others nearly equivalved; they have a row of about nine cartilage pits near the hinge, and are attached by a byssus. Eighteen species are found in tropical seas.

Genus *Pinna*. Shell acutely triangular, thin, translucent, and brittle, equivalved; hinge toothless, mantle of animal doubly fringed, foot elongated and grooved. Pinna spins itself a powerful byssus, by

which it is attached. The great *Pinna* excels any other in the quantity and fineness of its silk byssus, which has been woven into articles of dress. In early times these were so highly prized as to be worn only by emperors and kings. At Taranto, in Italy, it is still mixed with about one-third of real silk, and made into gloves, caps, stockings, &c., of a beautiful brownish colour. These are valued as objects of curiosity, but too expensive for general use, the price of a pair of gloves on the spot being about six shillings, and that of a pair of stockings eleven.

A specimen of this manufactured molluscan silk, as well as the raw material, may be seen in the Shell Gallery of the British Museum, beside the valves of the great Pinna. This is one of the largest bivalves, attaining a length of two feet. It lives from low water to sixty fathoms.



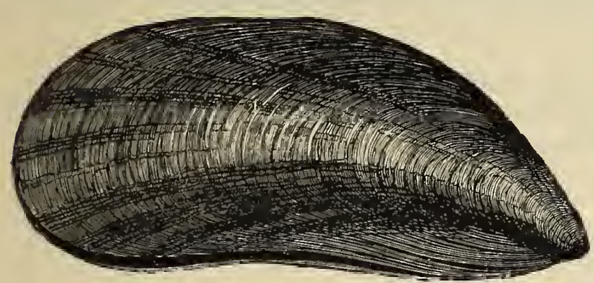
PINNA NOBILIS, WITH ITS BYSSUS.

FAMILY V.—MYTILIDÆ.

The shell of the Mussel is oval and equivalved, the edges closely fitting, the ligament internal, hinge toothless; they are mostly marine and attached by a byssus. Some of the members of this family exhibit a propensity for concealment, frequently spinning a nest of sand and shell-fragments, burrowing in soft substances, or secreting themselves in the burrows of other shells. Others are gregarious, living in vast beds of tens of thousands clustered together, adhering by their thread-like byssus.

Genus *Mytilus.* The "Sea Mussel" has a wedge-shaped shell, with the umbones at the end; it moors itself to piles and stones by a strong and coarse byssus. *Mytilus edulis*, the common edible Sea Mussel, although far less highly esteemed than the Scallop or Oyster, is nevertheless much in request as an article of food. It is difficult to ascertain the consumption of Mussels in London, but in Edinburgh and Leith it is estimated at 400 bushels annually. Dr. Knapp states that from thirty to forty millions are collected yearly in the Firth of Forth alone, and used as bait for the deep-sea fishery. They form no small item of consumption in the north of Ireland, boats full being constantly sent to Belfast Market.

If any one should reflect upon the *Mollusca* as undeserving so much notice, and mention the *Teredo* as an instance of a destructive member of the class, let him read of the utility of another, the common Mussel, in maintaining the long bridge of twenty-four arches across the Towridge River, near its junction with the Taw, at the town of Bideford, in Devonshire. At this bridge the tide runs so rapidly that it cannot be kept in repair with mortar. The Corporation, therefore, keep boats employed in bringing Mussels to it, and the interstices of the bridge are kept filled with Mussels. It is supported from being driven away by the tide entirely by the strong threads of the byssus which these Mussels fix to the stonework.



THE SEA MUSSEL.

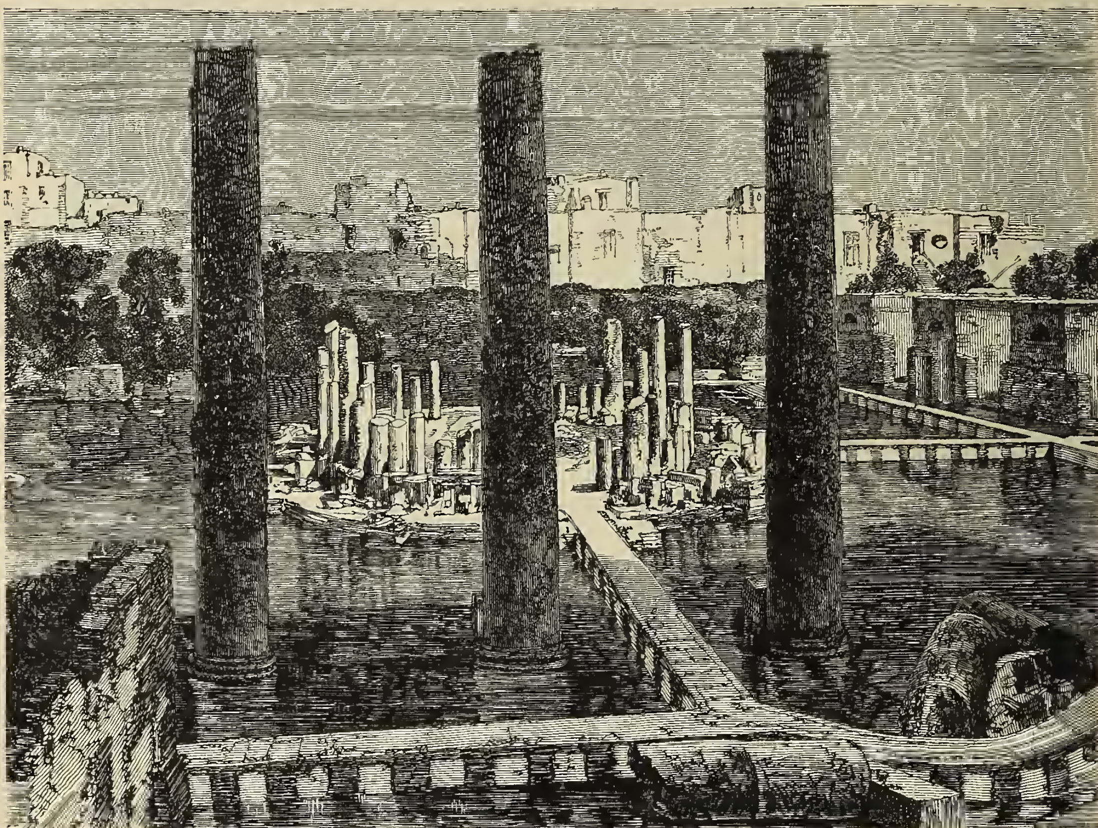
"*Mytilus edulis* is no friend to the Oyster. A colony of Mussels will, unknown to the proprietor of the Oyster bed, often settle upon the *spem gregis* of 'half ware,' so carefully deposited to grow fat. The Mussels, immediately on settling down, spin their curious silk-like webs, as seen under piers, &c., by means of which they are enabled to anchor themselves so firmly. The run of the tide then brings mud, the webs of the Mussels collect it, and the Oysters underneath, unless released by the dredge, are smothered like the little princes in the Tower." (Frank Buckland.)

Mussels are found living in all seas. About seventy species have been described.

Genus *Modiola*, the "Horse Mussel," is distinguished from the edible Mussel by its habit of burrowing; they are met with from low water to 100 fathoms. The shell is oblong and inflated, but

the umbones are not at the extreme termination of the shell, as in *Mytilus*. Seventy species are found in tropical seas.

Lithodomus, the Date-shell, bores into corals, and even hard limestone rocks. The animal, which is like the common Mussel, is eaten in the Mediterranean. Perforations made by *Lithodomi* in limestone cliffs and in the columns of the Temple of Serapis, at Puteoli, have afforded conclusive evidence of changes in the level of the sea-coasts in modern times. (Lyell.)



THREE ERECT COLUMNS OF THE TEMPLE OF SERAPIS AT PUTEOLI BORED BY LITHODOMI.

Genus *Dreissena*. The animal bears a triangular fan-shaped shell; the mantle is closed throughout, except for the passage of the foot, and of two tubular orifices for the purposes of excretion and respiration. The right valve has a slight byssal sinus. "*Dreissena polymorpha* is a native of the Aralo-Capian rivers. In 1824 it was observed by Mr. J. Sowerby in the Surrey Docks, to which it appears to have been brought with foreign timber in the holds of vessels. It has since spread into the canals, docks, and rivers of many parts of England, France, and Belgium, and has been noticed in the iron water pipes of London." (S. P. Woodward.)

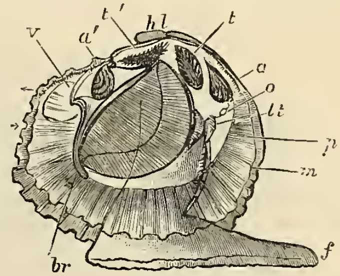
FAMILY VI.—ARCADÆ.

The shell is covered with a strong epidermis hinge line, often elongated and toothed; the valves are tumid and equal. The foot of the animal is large, curved, and deeply grooved.

Genus *Arca*. The "Arks" have thick, inflated, ribbed, and striated shells; the umbones anterior are divided by a lozenge-shaped hinge area; the foot is long and pointed, the mantle bears ocelli on its border. One division of the Arcs (*Byssoarca*) have a wide byssal aperture, filled with a horny cone; these conceal themselves under stones at low water, in crevices of rocks, and the empty burrows of boring molluscs. They inhabit all the warm seas of the globe, from low water to more than 200 fathoms. One species lives in the Ganges, 1,000 miles from the sea. (Benson.)

Cucullea resembles *Byssoarca*, but the valves are squarish and striated, and fit close together. Two species are found living in Nicobar, China, &c.

The characters of the genus *Pectunculus* are—shell nearly circular, valves equal, striated radially, hinge thick, with a row of teeth, and a ligament area between the beaks of the valves. The animal has a large foot, and the mantle is open and provided with ocelli. Fifty-eight species are found living in the West Indies, Britain, New Zealand, &c.



ANATOMY OF TRIGONIA PECTINATA.*

Genus *Limopsis* is like a small oblique *Pectunculus*, with a triangular cartilage pit in the centre of its hinge. Four species are known living in the Red Sea, Japan, Britain, &c.

Genus *Nucula.* In this genus the valves are somewhat triangular, with their beaks turned backward; interior of valves pearly, hinge with a large cartilage pit, and numerous sharp teeth on each side. The Nuculæ are burrowers, and have very wide distribution, from Norway to Japan, living from five to more than 100 fathoms in depth. Seventy living species are known.

Genus *Leda* resembles *Nucula*, but the shell is more elongated and pointed behind. It is found in the Northern and Arctic seas, living from ten to 200 fathoms.

Genus *Solenella.* In this genus the shell is nearly oval; the valves are pearly within; the hinge ligament is external; the line of the mantle has a large and deep fold; the siphonal tubes are joined together; they are long and slender, and can be drawn completely into the shell. They are found living at Valparaiso, New Zealand, &c.


TRIGONIA COSTATA.

Genus *Solemya.* The valves of the shell are somewhat cylindrical and elongated, and gape at each end. They are covered with a dark horny epidermis, which overlaps the margins. There are no hinge teeth. Four species only are known in America, Africa, and the Canaries.

FAMILY VII.—TRIGONIADÆ.

The shells of this family have the valves equal, triangular in form, closely fitting, with the umbones of the valves turned backwards. The hinge teeth are diverging, the border of the mantle is simple, the interior of the shells pearly; the hinge ligament is external. The foot is long and curved; there are two gills on each side, and the mantle is open.

In the genus *Trigonia* the shell is thick and ornamented with tubercles, or with ribs arranged in concentric or radiating lines; the posterior side of the valves is angular; the shells are almost entirely composed of pearl. Like the young Pectens, the *Trigoniæ* are very active bivalves. A *Trigonia*, taken alive from the dredge by Mr. S. Stutchbury, and placed on the gunwale of the boat, leapt overboard, clearing a ledge of four inches. They are probably migratory, as in dredging for them it is very uncertain where they may be obtained, though they abound in some parts of Sydney Harbour. *Trigonia* is almost an extinct form, three species or varieties only being known living in Australia, whilst more than one hundred are found fossil, widely distributed over the globe.

TRIGONIA PECTINATA.†

FAMILY VIII.—UNIONIDÆ.

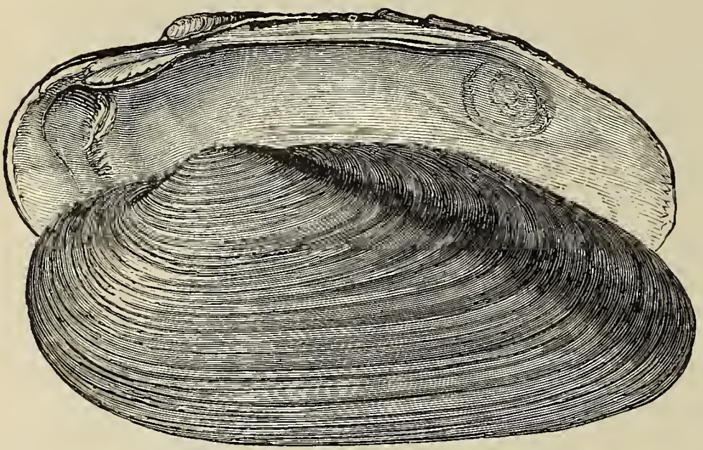
The animal bears a pearly shell, with the mantle lobes freely open except behind, where they are united to form the branchial and excretory siphonal orifices, which are simply pouted. The foot is large and free.

* Explanation of the lettering in this figure:—*a*, anterior adductor muscle; *a'*, posterior adductor muscle; *h l*, hinge ligament; *t t'*, pits for the reception of teeth in the right valve; *f*, foot; *v*, excreting orifice; *m*, free margin of the mantle; *o*, the mouth; *p*, line (corresponding with the pallial impression in the shell) from which the muscular fibres of the mantle originate. The central portion of the mantle is thin and transparent. Through it are seen—*b r*, the right branchial leaves; and *l t*, the labial tentacles of the right side of the mouth. The arrows indicate the points at which the respiratory currents enter and escape.

† *f' f*, hinge-teeth and sockets; *a' a*, adductor muscles.

Genus *Unio*, the "River Mussel." The shell is rather stout; the hinge is composed of interlocking erect teeth on the anterior side, and elongated marginal teeth, which are sometimes obsolete, on the posterior.

The Pearl-bearing Mussel (*Unio margaritifera*) afforded the once famous British pearls. It is found in the mountain streams of Britain, Lapland, and Canada, and is used for bait in the Aberdeen Cod fishery. The Scottish pearl fishery continued till the end of last century, especially in the River Tay, where the Mussels were collected by the peasantry before harvest time. The pearls were usually found in old and deformed specimens. Round pearls, about the size of a pea, perfect in every respect, were worth £3 or £4. An account of the Irish pearl fishery was given by Sir R. Redding, in the *Philosophical Transactions*, 1693. The Mussels were found set up in the sand of the river-bed, with their open side turned from the torrent; about one in a hundred might contain a pearl, and one pearl in a hundred might be tolerably clear.



UNIO PICTORUM.

Hyria is the shell which the Chinese employ to produce artificial pearls, by the introduction of shot, &c., between the mantle of the animal and its shell. A *Hyria* in the British Museum has a number of little josses made of bell-metal, now completely coated with pearl, in its interior. The river Mussels are found in the ponds and streams of all parts of the world. In Europe the species are few, though specimens are abundant; in North America, both species and individuals abound. All the remarkable generic forms are peculiar to South America and Africa.

Genus *Anodon*. The shell is thin and toothless. This is the largest of European fresh-water molluscs. It has a very inflated shell; the valves, although toothless, are united by a strong external ligament; the foot of the animal is very large, and of an orange-yellow colour. The lakes, canals, ponds, and gently-flowing rivers through Europe, are all tenanted by *Anodonta*. They are very abundant in North and South America. Several hundred species have been described, but they are, in all probability, capable of being reduced to half a dozen, so great are the variations which these shells present.

ANODONTA ENSIFORMIS.

Nearly all the great rivers of the world have some characteristic form of the genus *Unio*. Thus *Castalia* is peculiar to the rivers of South America, especially the Amazon. *Iridina* occurs in the rivers of Africa, as the Nile and Senegal. *Mycetopus*, a *Solen*-like form of *Unio*, is found in South America only.

Two genera (*Ætheria*), from the River Nile (first noticed by the African traveller Bruce as a "fresh-water Oyster"), and *Mulleria*, from New Granada, are fixed and irregular when adult, and have been placed with the *Chamas* and Oysters by the admirers of artificial systems; fortunately, however, M. D'Orbigny has ascertained that the *Mulleria*, which is fixed and mono-myary when adult, is locomotive and di-myary when young, like any other *Unio*. (S. P. Woodward).

Mollusca inhabiting fresh water are especially exposed to corrosive action, either from carbonic acid in solution or dilute sulphuric acid from the decomposition of iron pyrites. But the action is especially manifested in those stagnant waters where the first probe of the collecting-rod disengages

* Latin, *unio*, a pearl.

from the mud an abundant stream of bubbles of sulphuretted hydrogen. In such situations the spiral shells—for example, *Bithynia*—have lost the ends of their spires, and the discoidal shells, like *Planorbis*, have been found with a small hole caused by the dissolution of the inner whorls. The great and ponderous Mussels of the American rivers, and even the fresh-water *Unios* and *Anodons* of our own streams, are often externally eroded, and the cause has been the subject of much speculation. The umbo is the part first formed, and consequently that where the epidermis is thinnest and has been longest exposed to the action of the elements, and it is this portion of the shell which is most corroded.

Division b. SIPHONIDA.—In this section the animals have respiratory siphons, and the lobes of the mantle are usually united. In the first subdivision the siphons are short and the pallial border is simple.

FAMILY IX.—CHAMIDÆ.

The shells in this family are thick, the valves unequal, the hinge teeth two in one valve and one in the other; the ligament is external.

Genus *Chama.* These shells are found only in tropical seas among coral reefs. They are attached indifferently by either valve. When the right valve is fixed the dentition is reversed, the left valve having the single tooth. The exterior of the valves is ornamented with a succession of brightly-coloured frills.

FAMILY X.—TRIDACNIDÆ.

The valves are strongly ribbed and toothed at the margin, the hinge ligament is external, the shells are equal. Sometimes the animal is attached by a byssus, in others it is free.

The genus *Tridacna* is the largest of the whole class of bivalves. The Giant Clam (*Tridacna gigas*) of the Indian Ocean, the shell of which often weighs upwards of 500 lbs., contains an animal weighing sometimes 20 lbs., which is stated by Captain Cook to be very good eating. Darwin, in his "Voyage of a Naturalist Round the World," in describing Keeling Atoll says—"We stayed a long time in the lagoon, examining fields of coral and the gigantic Clam-shells, into which if a man were to put his hand he would not as long as the animal lived be able to withdraw it." The Paphian Venus, springing from the sea, is usually represented as issuing from the opening valves of a *Tridacna.* The huge valves of this shell are frequently used for holy water in churches. Two weighing 500 lbs. and measuring more than two feet across may be seen in the church of S. Sulpice, Paris. (Dillwyn.)

TRIDACNA SQUAMOSA—A, OUTSIDE, AND B, INSIDE OF SHELL.

FAMILY XI.—CARDIADÆ.

The Cockles live unattached; their valves are equal and nearly bilaterally symmetrical; the surface of the shells are ribbed radially; the siphons are short; there are two gills on each side; the foot is large and recurved.

In *Cardium* the shell is inflated, the umbones prominent; the hinge has two lateral teeth, one in each valve. The margins of the valves are crenulated. The common Cockle (*Cardium edule*) is largely used in many parts of England for food. It is obtained at extreme low water on all sandy shores, living buried in the sand. It ranges from the Baltic southward, and is found in the Black Sea and Caspian. Two other much larger species occur on the British coast, viz., *C. rusticum*, and the Prickly Cockle (*C. aculeatum*). Both of these are edible, but the small species is the one so largely consumed in all parts of Britain.

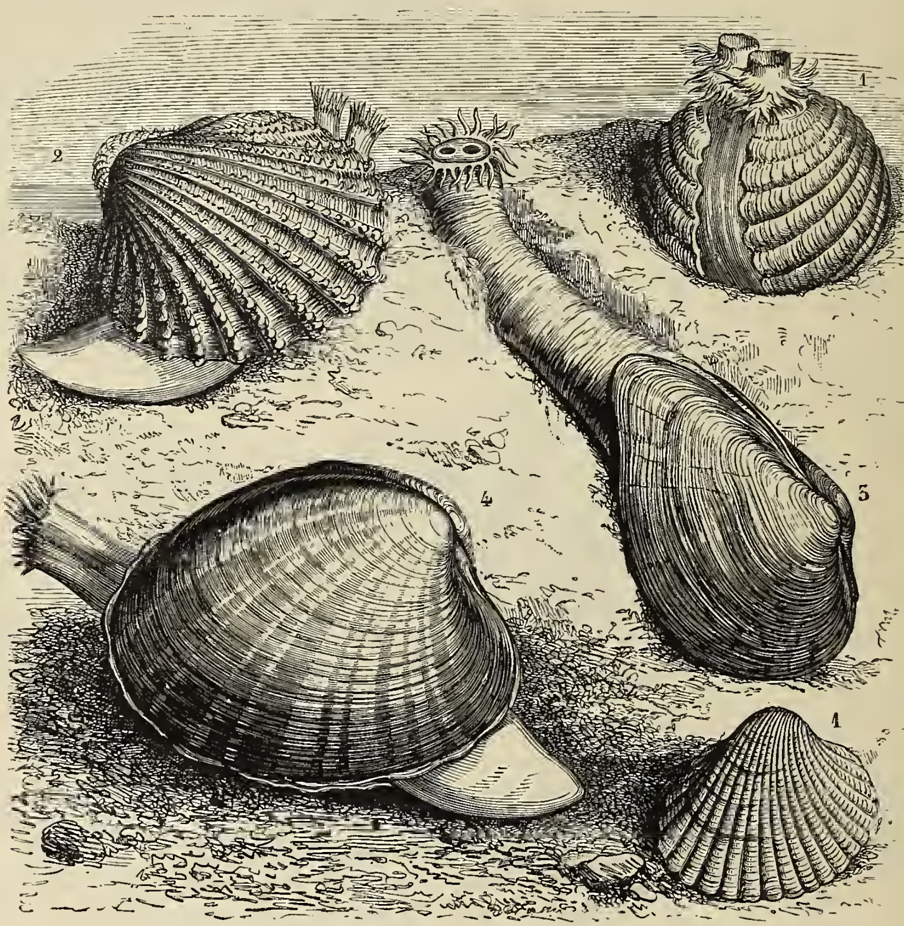
FAMILY XII.—LUCINIDÆ.

The valves of the shell of this family are circular, closely fitting, and unattached; the surface of the shell is dull; the foot is long and cylindrical.

The shell in the genus *Lucina* is white, the umbones of the valves small and compressed. The margins of the shell are smooth or finely crenulated; the ligament is concealed, the hinge teeth are lateral. The foot is often twice as large as the animal.

The *Lucinæ* occur in tropical and temperate seas, on both sandy and muddy bottoms, from low water to near 200 fathoms.

In *Corbis* the valves of the shell are elegantly sculptured concentrically, and the margins finely toothed within. Five species occur in the Indian and Pacific Oceans. In *Diplodonta* the shell is very like *Lucina,* but with a rather long double ligament, and two hinge teeth. Their distribution



1, CARDIUM EDULE; 2, CARDIUM ECHINATUM; 3, MYA ARENARIA; 4, CYTHEREA CHIONE

is world-wide. *Ungulina* has a more oblong form than *Diplodonta,* with a short ligament and thick epidermis. It burrows in coral, and is found in Senegal and the Philippines. The minute orbicular shell of the genus *Kellia* is very thin. The animal creeps freely, and fixes itself by a byssus at pleasure. One species (*K. rubra*) is found in crevices of rocks at high water; others range to a depth of 200 fathoms in Norway, New Zealand, and California. Genus *Montacuta,* another small form, walks freely on a large and broad foot, and attaches itself to the spines of the Purple-heart Urchin; others burrow into the valves of dead shells. *Lepton* has a thick tapering foot, forming a creeping disc. The mantle extends beyond the shell, bearing a fringe of filaments. Genus *Galeomma* has a thick fibrous epidermis. The foot is long and narrow, with a flat sole. It spins a byssus, which it breaks at will, and creeps about like a snail, spreading out its valves nearly flat.

FAMILY XIII.—CYCLADIDÆ.

The animal has a thin, horny shell, with the mantle lobes partly open for the passage of a large protruded foot, and united posteriorly to form the branchial and excurrent siphons, which are prolonged into tubes wholly or partially united.

In *Cyclas* the animal is ovo-viviparous. The gills are large, the valves of shell are nearly equal, and much inflated. The young of *Cyclas* are hatched in the gills of the parent. They vary in size from one-sixth to one-quarter the length of the mother. They are very active, climbing in aquatic plants, attaching themselves by delicate threads. They chiefly inhabit the temperate regions of the globe in both hemispheres.

The shells of *Cyrena* are covered with a rough epidermis; they are oval and thick, and have three hinge teeth, and one lateral tooth in each valve; the foot is strong and tongue-shaped. This mollusc is found abundantly in the Nile and other Eastern rivers to China, and in mangrove swamps, usually near the coast. It is particularly interesting to geologists, being found in the old river deposits of the Thames, &c., associated with the remains of elephants, &c.

FAMILY XIV.—ASTARTIDÆ.

The characters in this family are, shell free; oblong or nearly round; surface of valves often concentrically ribbed, and covered with a brown epidermis; hinge with strongly developed cardinal teeth. All the genera are marine.

The shell of *Astarte* is thick; the valves are somewhat round, and compressed towards the beaks; they are smooth or concentrically furrowed; there are two hinge teeth in each valve; the hinge ligament is external. Of the twenty species known, by far the larger number are Arctic, being met with by our Polar expeditions, both living and as dead shells, on raised beaches far above the present level of the sea.

Genus *Crassatella*. The shell is oblong, attenuated behind; the valves are very thick, smooth, or furrowed concentrically; the ligament is internal; the muscular impressions are deep, rounded, distinct; the mantle line is simple. Thirty-four species are living in Australia, the Philippines, Africa, &c.

FAMILY XV.—CYPRINIDÆ.

About half of this family are fossil, and the rest were more abundant in the Tertiary period than at the present time. The valves are equal, round, or elongated, solid, closely-fitting, with a thick dark epidermis; the hinge ligament is external; there are hinge teeth, one and three in each valve; the mantle border is simple.

In *Cyprina* the shell is large and strong, oval in outline. Like *Astarte*, *Cyprina* has an extreme northern range from Britain to Iceland, and northward as far as our explorers have advanced towards the Pole.

The genus *Circe* has a thick, compressed orbicular shell, ornamented with diverging striæ; the valves are compressed, and the umbones flat; hinge teeth three and three. Forty living species are found in Australia, India, the Red Sea, Britain, &c.

In the "Heart Cockle" (*Isocardia*) the valves are smooth, inflated; the umbones are distant, and somewhat spiral; the hinge ligament is external; hinge teeth two and two, lateral teeth one and one, in each valve. It burrows in the sand. Five species are living in the Mediterranean, China, and Japan.

Cypricardia dwells in the crevices of rocks and coral, and is found in the Red Sea and Indian Ocean.

In *Cardita* the hinge ligament is external, the margins are toothed, the hinge teeth are one and two; the shell is narrow and oblong, and radially ribbed. Fifty-four species are found living, chiefly in tropical seas. It had a more extensive distribution in past geological times.

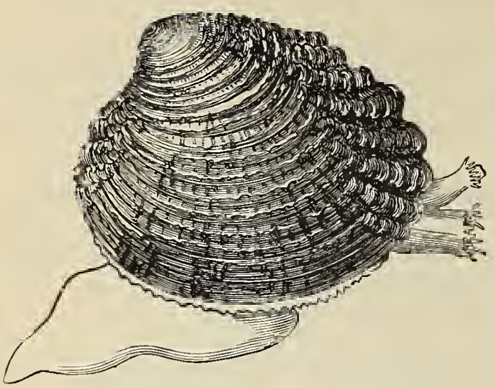
In Subdivision 2 the animals have long respiratory siphons, and the pallial border is recurved.

FAMILY XVI.—VENERIDÆ.

These bivalves are free, and do not live attached to other bodies by a byssus, nor do they bore into rocks, but live simply in sandy or muddy sea-bottoms, into which they burrow by means of their tongue-shaped foot. The siphons are unequal—retractile; the hinge ligament is external; the shell is regular and closely fitting, more or less circular or oval in outline, with three teeth in each valve. The shells of this family are hard, solid, and generally marked by elegance of form and coloration.

In *Venus* the mantle margins are fringed; the siphons are unequal and separate; the shell is thick

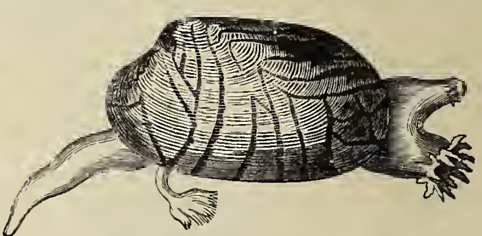
ovate, and tumid, the valves grooved or lamellate; the margins of the shell finely crenulated; the lunule is distinct, the hinge thick, with three teeth in each valve; line of the mantle has a short angular bend. One hundred and seventy-six species of this genus are found living, with a world-wide distribution, in the British Islands, North Sea, Mediterranean, Cape of Good Hope, &c. They are found buried a few inches deep in sand at low water, and range to 100 fathoms; they are all edible. The North American Indians used to make coinage ("wampum") of the sea-worn fragments of *V. mercenaria* by perforating and stringing them on leather thongs. Long Island was called *Seawar hackee* (or Shell Island) by the Moheyan Indians, who resorted to it to collect Seawan ("wampum shells"), from which they made their purple beads. *V. mercenaria* ranges from Cape Ann, Mass., to Delaware Bay; it is called the "round clam"—"quahog." It sells from 37½ to 62½ cents the bushel.



VENUS VERRUCOSA, WITH ITS ANIMAL.

Genus *Cytherea.* The shell is like *Venus*, but the margins are smooth; the border of the mantle is plain, and the siphons are partly united. One hundred and thirteen species are living.

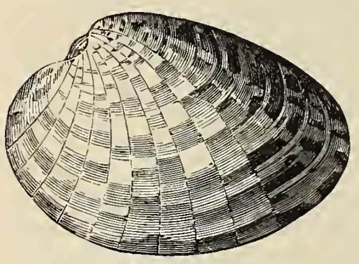
Genus *Artemis.* At first sight *Artemis* looks like a *Lucina*, but the outline is almost circular, and it has a deep angular pallial fold; the hinge is like *Cytherea*; the foot is large and hatchet-shaped; the siphons are united; the margin of the mantle is plaited. *Artemis* ranges from northern to tropical seas, and from low water to 100 fathoms. One hundred species are known.



CYTHEREA GEOGRAPHICA, WITH ITS ANIMAL.

Genus *Lucinopsis.* The shell is less elegant in outline than in *Artemis*, and thinner; the right valve has two diverging teeth, the left has three; the mantle-fold is very deep; the siphons are longer than the shell, and diverge from one another; their orifices are fringed. Ten species are living in North America, Norway, the Mediterranean, and Britain. It is also found fossil.

Genus *Tapes.* The outline of the shell is ovate, oblong; the umbones of the shell turned forward; the margin smooth; the siphonal fold deep and rounded. The animal is eaten in North America and on the coast of Europe; it lives burrowed in the sand from low water to 100 fathoms. Nearly eighty species are known living.



CYTHEREA MACULATA.

The genus *Venerupis* lives in crevices of rocks; the shell is oblong and ornamented with concentric raised lamellæ, and striated radially. Twenty species are living in Britain, the Canaries, India, Peru, &c.

The genus *Petricola* burrows in limestone and mud; the shell is oval and thin. Thirty species are living in the United States, New Zealand, &c.

Genus *Glaucomya.* The shell is shaped like a Mya, but with three teeth in each valve. The siphonal fold is deep and angular; the valves are covered with a dark green epidermis; the siphons are very long. Twelve species are living near the mouths of rivers in India, China &c.

FAMILY XVII.—MACTRIDÆ.

The *Mactridæ* have somewhat triangular equal valves, mostly close fitting; they have a deep pit for the hinge ligament, triangular in form; the hinge has two diverging teeth; the siphonal fold is short and rounded; the epidermis is thick.

Mactra * has a large tongue-shaped foot; the siphons are united and fringed; the shell is

* Latin, *mactra*, a kneading trough.

nearly equilateral. The Mactras inhabit sandy coasts, burrowing just below the surface. Mr. Alder says that in the island of Arran *M. subtruncata* is collected at low water to feed pigs on; they are also eaten by the Starfishes and Whelks. One hundred and twenty-five species are known living. They are world-wide in their distribution, being especially abundant within the tropics.

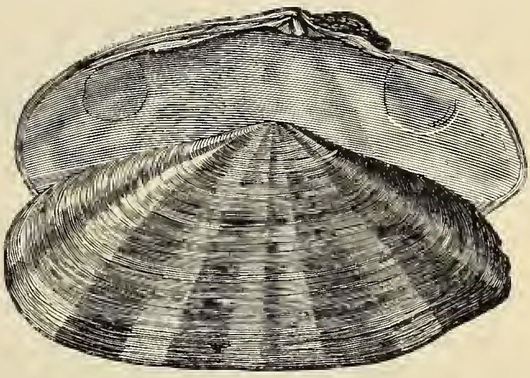
The shell of *Gnathodon* closely resembles that of *Cyrena* in form, the valves being thick and smooth, and covered with a green epidermis; the hinge has two teeth and a deep central cartilage pit; the siphonal fold is moderately deep. Sir Charles Lyell mentions that *G. cuneatus* was formerly eaten by the Indians. At Mobile, on the Gulf of Mexico, it is found with *Cyrena Carolinensis* burrowing two inches deep in mud. The water is brackish, though there is a tide of three feet. The city of Mobile is built on one of these shell-banks. The road from New Orleans to Lake Pontchartrain is made of Gnathodon shells procured from the lake, where there is a mound at the east end a mile long and fifteen feet high, and twenty to sixty yards wide.*

The genus *Lutraria* has a very oblong shell, open at both ends; it has a prominent cartilage pit and two small teeth in each valve; the fold for the siphons is deep and round; the foot is large and compressed; the shell is covered with epidermis. It inhabits the mud of estuaries. Eighteen species are known, widely distributed.

The genus *Anatinella* has an ovate shell; the cartilage is in a spoon-shaped process within the valves; there are two small hinge teeth; the pallial line is nearly entire. Three species are living in Ceylon and the Philippines.

FAMILY XVIII.—TELLINIDÆ.

The shell has equal valves, closed and compressed; the cardinal teeth are two; the siphonal fold is large; the foot is tongue-shaped; the siphons are separate, long, and slender. "The Tellens are found in all seas, chiefly in the littoral and laminarian zones; they frequent sandy bottoms or sandy mud, burrowing beneath the surface; a few species inhabit estuaries and rivers. Their valves are often richly coloured and ornamented with finely sculptured lines." (S. P. Woodward.)


TELLINA RADIATA.

Genus *Tellina*. The shell is ovate, oblong, rounded in front, angular behind; the valves smooth or marked with radiating striæ. The most beautifully coloured *Tellinæ* are found in the seas of tropical regions. The animals have the power of leaping from the surface by means of their muscular foot. More than 300 species have been described.

Genus *Gastrana*. The shell is triangular, valves equal and convex; there are two cardinal teeth in the right valve and one in the left; the siphonal fold is deep and rounded. *Gastrana* bores in mud and clay, and does not move about freely like *Tellina*. Three species are known from South Africa.

Genus *Capsula*. The shell is ovate, long, open at each end; it is striated radially; there are two hinge teeth in each valve; the animal resembles *Psammobia*, but the siphons are shorter. Four species are living in the West Indies, China, &c.

Genus *Psammobia*†, "Sunset shell." The surface of the valves are smooth or radiately striated, the siphons very long and slender. They inhabit sand and mud, and range from the littoral zone to a depth of 100 fathoms. A few inhabit British shores, and others with very delicate and beautifully rayed shells are natives of the Pacific and Indian Oceans, &c.

Genus *Sanguinolaria*. The shell is ovate oblong, round in front, attenuated and gaping behind, the pallial fold is very deep; the hinge ligament external; the teeth small, two in each valve; the siphons very long; the foot large and tongue-shaped. Twenty species are found living in the West Indies, Australia, Peru, &c.

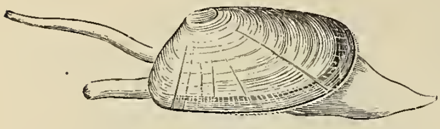
The genus *Semele* has a shell like a *Tellina* in shape, with two hinge teeth in each valve, the

* "Second Visit to the United States," vol. ii., p. 106.

† Greek, *psammos*, sand; *bios*, life.

ligament is external and short, the cartilage internal and long, the siphonal fold deep. Sixty species are known from Brazil, India, China, &c.

Genus *Mesodesma*.* The valves of shell are thick, triangular, closed; the ligament is internal; there are lateral teeth in each valve; the siphonal fold is small; the muscular impressions are deep. Thirty-one species occur in the West Indies, Chili, and the Mediterranean.



DONAX TRUNCULUS.

Genus *Ervillia*, "Lentil-shell." The shell is oval and small, with a single prominent tooth to the hinge in right valve, and two obscure teeth in left valve. The siphonal fold is deep. Two species are living at fifty fathoms in the West Indies, &c.

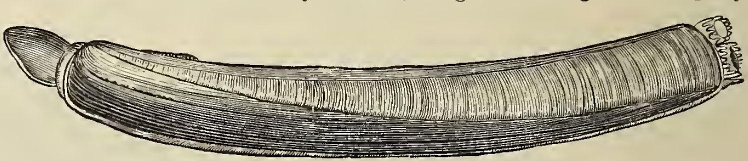
In the genus *Donax* the shell is wedge-like, somewhat triangular, rounded in front, truncated behind; the border of the valves is crenulated; there are two hinge teeth in each valve, and the ligament is external. Sixty-eight species are known, found living in Norway, the Baltic, &c.

The genus *Galatea* has a very thick, wedge-shaped, triangular shell, with an olive-green epidermis; the hinge is strong, with three teeth and an external prominent ligament, the siphonal fold is distinct. This is a fresh-water shell, inhabiting the rivers of Africa. Six species are known.

FAMILY XIX.—SOLENIDÆ.

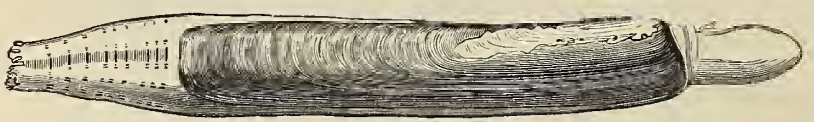
The shell is more or less elongated, open at each end; the hinge ligament is external; there are cardinal teeth, two in the right valve and three in the left. The *Solens* have a large and powerful cylindrical foot; the siphons are short, and the gills narrow.

Genus *Solen*, "Razor-fish." The shell is somewhat cylindrical, long and straight, or slightly curved, margins parallel, ends gaping, hinge line elongated, ligament external, foot cylindrical, obtuse. The *Solens* are of world-wide distribution, except in the colder seas. The Razor-fishes are powerful burrowers; they never willingly leave their burrows; they may, however, be caught with a bent wire, and are good eating when cooked.



SOLEN ENSIS.

Genus *Solecurtus*. The shell is ovate oblong, the umbo small, margins almost parallel, ends rounded, gaping; the hinge ligament is external; there are two hinge teeth in each valve; the siphonal fold is very deep; the animal is entirely retractile within the shell. The *Solecuti* bury themselves in sand and mud, and are difficult to obtain alive. *S. caribæus* occurs in countless numbers in the bars of American rivers. By removing three or four inches of san dits burrows may be discovered; they are vertical cavities one inch and a half in diameter, and twelve or more deep; the animal holds fast by the expanded end of its foot. (S. P. Woodward.) Twenty-five species are known in Britain, Africa, Madeira, the Mediteranneau, &c.



SOLEN VAGINA.

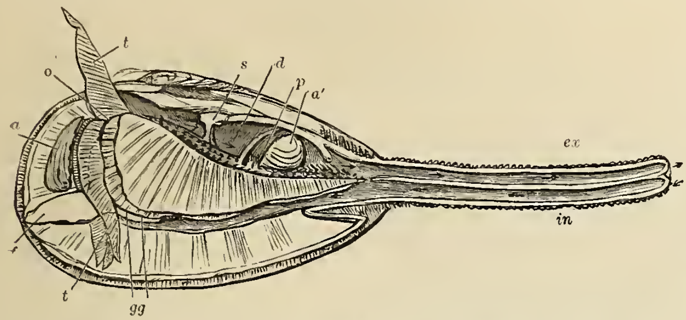
FAMILY XX.—MYACIDÆ.

The valves of the shell are gaping behind, opaque and strong, covered with a wrinkled epidermis; the mantle is almost closed; the foot small; the siphons united and retractile.

Genus *Mya*, "Gaper." The shell is gaping at the ends; the left valve smaller than the right, with a large process for the cartilage; the siphonal fold is large; the epidermis extends over and encloses the siphons, which are partially retractile. Some of the species of *Mya*, as *M. arenaria* and *M. truncata*, have a high northern range, being found through the Arctic seas; they are considered excellent food, and are not only eaten by man, but by the walrus, the Arctic fox, and even by birds. Ten species are known living.

* Greek, *mesos*, middle, and *desmos*, ligament.

Genus *Corbula.* The valves of this shell are very unequal, and produced behind; they do not gape; the right valve, which is the largest, has a prominent tooth in front of the cartilage pit; the smaller left valve has projecting processes; the siphons of the animal are short and united, the foot is pointed. There are sixty species living. It inhabits the lower laminarian zone, and dwells in eighty fathoms.



ANATOMY OF SOFT PARTS OF MYA ARENARIA.

a, the Anterior, and *a'*, the Posterior Adductor Muscle; *ex*, the Excurrent, and *in*, the Incurrent Siphon; *g g*, the Gills, or *Branchiæ*; *f*, the Foot *tt*, the Labial, or Lip-tentacles; *o*, the Oral Aperture, or Mouth; *s*, the Stomach; *d*, the Intestine opening into the Excurrent Siphon; *p*, the *Pedal*, or Foot, Muscle.

Genus *Thetis.* This shell is nearly circular; the umbones are prominent; the valves are translucent and inflated; the interior is slightly pearly; there are one or two hinge teeth; the ligament is external; the pallial line simple. Five species are found living in Britain, France, India, &c.

Genus *Panopæa.* In this genus the valves are equal; they are thick, more or less oblong, and open at either end; the hinge ligament is external; there is a prominent tooth in each valve; the siphonal indentation is deep. This is an Arctic form, extending from the White Sea to Norway and Britain. The Panopæas are great burrowers; they dwell from low water to 100 fathoms. The shell attains a length of six or eight inches. Eleven species are found living in the North Seas, Mediterranean, &c.

Some of the British shells fetch high prices on account of their rarity, although their appearance is by no means attractive. The rude-looking bivalve called *Panopæa norvegica* cannot be obtained for less than three guineas; and there is an unusually good specimen in the collection of Mrs. De Burgh, which was offered to the British Museum for six guineas and declined, but afterwards realised nearly that amount. *Tellina balaustina* is a much smaller but brightly-tinted shell, of which there is a specimen in the British Museum worth three guineas.

FAMILY XXI.—ANATINIDÆ.

The *Anatinidæ* have thin, nacreous, inequivalve shells, with an external ligament and an internal cartilage; the siphons are long and united; the gills are single on each side. A large proportion of this family only occurs fossil.

Genus *Anatinia*, "Lantern-shell." The hinge is provided with a spoon-shaped cartilage process in each valve; the siphons are long, united, covered with wrinkled epidermis; there is one gill on each side; the foot is very small. Fifty species are found living in India, West Africa, the Philippines, and New Zealand.

Genus *Thracia.* *Thracia pubescens* and *Anatina subrostrata*, and its sub-genus *Periploma prætenue*, are all closely allied forms of the family *Anatinidæ.* There are seventeen species of *Thracia*, extending from Greenland to the Canaries and China, living at a depth of from four to 120 fathoms.

Genus *Pholadomya.* The shell is transversely oblong, equivalve, thin, white, and translucent, gaping at both ends, pearly inside; the surface of the valves is ornamented with radiating ribs. Although 160 species are known fossil, only one recent form is known, which is occasionally met with on the shores of the Island of Tortola, in the West Indies, after hurricanes, being probably thrown up from deep water by the force of wind and waves.

Genus *Lyonsia.* The valves of this shell are thin, somewhat pearly, the left being a trifle the largest; the posterior end is truncated; the cartilage plates are oblique; the animal has a tongue-shaped foot, which is grooved, and spins a byssus. Twelve species are known, ranging from Greenland to Madeira and the Indian seas.

Genus *Pandora.* This genus has thin, closely-fitting valves, pearly inside; the right valve is flat, with a diverging ridge and cartilage; the left valve is deep, with two diverging grooves at the hinge; the foot is narrow, and the siphons very short. Eighteen species are known living, ranging from Spitzbergen to Panama, India, &c.

Genus *Myadora.* In *Myadora* the valves are exactly the converse of *Pandora,* the left being flat and the right convex. The outline is more triangular than that of Pandora, and there is a free sickle-shaped ossicle in the right valve and two tooth-like ridges in the left. Ten species are found living in New Zealand, New South Wales, and the Philippines.

Genus *Myochama.* In *Myochama* the animal is attached by the right valve, while the left is round; the cartilage is internal; there are two tooth-like projections in each valve. It is attached to *Trigoniæ* and *Crassatellæ.* Its habitat is New South Wales.

Genus *Chamostrea.* The shell is solid, and attached by the front side of the right valve, which is deep and strongly keeled. One species only is known, from New South Wales.

FAMILY XXII.—GASTROCHÆNIDÆ.

They have thin, gaping, toothless valves, united by a ligament, and cemented to a shelly tube when adult. The animal has two very long united siphons behind, and a truncated finger-like foot in front. The members of this family are burrowers, either in mud or stone, near low water.

Genus *Gastrochæna.** The shell is wedge-shaped, the umbones are turned forward, the valves gape widely in front and are closed behind. *Gastrochæna* perforates shells and limestone; its holes are regular, about two inches deep; the external orifice is hour-glass-shaped and lined with shell. Ten species are known in the West Indies, Britain, Red Sea, Pacific Isles, Panama, &c.

THE WATERING-POT SHELL, ASPERGILLUM.

Genus *Saxicava.* The young shell is said to be symmetrical and furnished with two teeth in each valve; but the adult is rugose, toothless, thick, oblong, gaping, with an external hinge ligament; the siphons are large and united near the ends. So variable is this shell that five genera and fifteen species have been named upon its aberrant forms. It conceals itself in the crevices of rocks and coral and amongst the roots of seaweed. At Harwich it bores into the clay ironstone, at Folkestone in the Kentish rag, and at Portland into the Portland oolite. Its crypts are six inches long. (Couch.) *Saxicava* ranges from low water to 140 fathoms; it is found in all Arctic seas. Specimens of *Saxicava arctica* were more abundant than any other shells brought home by the *Alert* and *Discovery* from the Arctic regions. Among this section of mollusca are some instances which present the phenomenon of an extensive geographical distribution, though their capabilities for locomotion are very limited. For instance, some species of *Saxicava arctica, Venus pullastra,* and *Pecten pusio* are found both on our northern coasts and at the Cape of Good Hope, though not in the intermediate tropical regions. The species of *Limacina* which belongs to the South Polar Ocean cannot be distinguished from the *Limacina arctica* belonging to the North; it has no representative in the intermediate seas. The same is the case with the genus of *Puncturella,* which embraces two species, of which the one belongs to the Arctic, the other to the Antarctic Seas, in the neighbourhood of Tierra del Fuego.

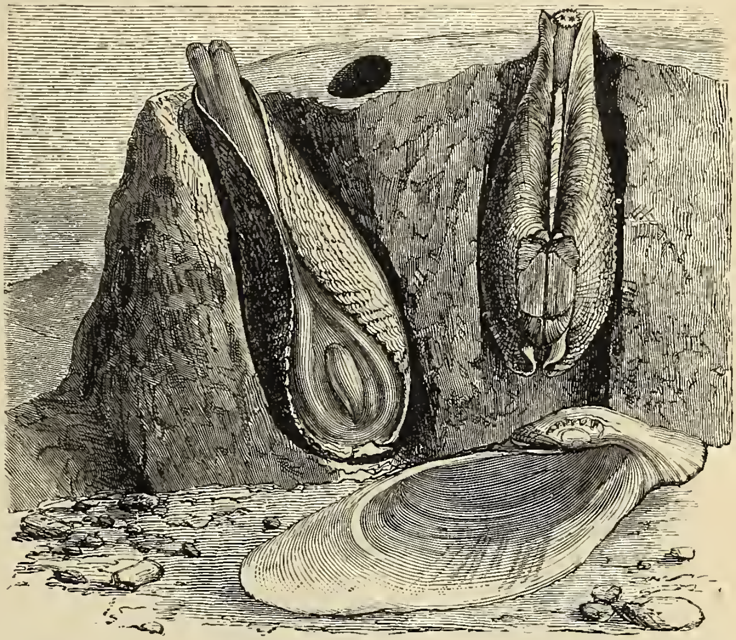
Genus *Clavagella.* In this genus the shell is oblong, irregular; the valves unequal, the right valve always free, the left embedded in the dilated hind part of the tube, which is shelly, cylindrical, attenuated, and open behind; the margin is simple or furnished with siphonal fringes. The anterior or lower end of the tube is club-shaped and either simple or surrounded by spine-like tubes; the mantle being furnished with tentacular processes forms these branching tubuli. Most of the *Clavagella* burrow in stone and coral. Six species occur in the Mediterranean, Australia, and the Pacific.

Genus *Aspergillum,* "Watering-pot Shell." In certain boring and burrowing bivalves, as *Gastrochæna, Clavagella,* and *Teredo,* the shell does not increase with age, but the siphons secrete a shelly tube in which the soft parts of the animal are encased, and the minute valves of the young mollusc are seen embedded in the wall. In *Aspergillum vaginiferum,* the Watering-pot Shell, the minute valves are also to be seen near the lower extremity of the tube, the siphonal end being plain, or ornamented with from one to eight frills. Twenty-one species occur in the Red Sea, Java, New Zealand, &c.

* Greek, *gaster,* ventral, and *chæna,* gape.

FAMILY XXIII.—PHOLADIDÆ.

The characters of this family are, shell free, or within a tube; valves equal, gaping at both ends, thin, white, brittle, armed in front with rasp-like imbrications, without hinge teeth, and strengthened externally by accessory valves; hinge-plate reflexed over the beaks, and furnished with a long, curved muscular process beneath each; anterior muscular impression on the hinge-plate, pallial sinus very deep. It lives perpendicularly in holes in the rock or sand. The *Pholadidæ* perforate all substances that are softer than their own valves (M. Cailliaud), but Mr. Hancock has pointed out that the foot appears to be a more efficient instrument than the shell, for burrowing into rock, seeing that its surface can be renewed as fast as it is worn away.



PHOLAS DACTYLUS IN A SHELTER HOLLOWED OUT BY IT IN A BLOCK OF GNEISS.

Genus *Pholas*. The common Piddock is used for bait on the coast of Devon; its foot is white and translucent when fresh. It has two accessory valves to protect the umbonal muscle, with a small transverse plate behind; a long unsymmetrical plate fills up the space between the valves in the dorsal region. Thirty-two species are found living at twenty-five fathoms. It is almost cosmopolitan. *P. costata* is sold as food in the market of Havannah.

Genus *Pholadidea*. This genus resembles *Pholas*, but has a deep transverse furrow across the centre of its valves; the anterior gape is large, but closed in the adult by a callous plate. Seven species are found, from low tide to ten fathoms, in Britain, New Zealand, and Ecuador. *Pholadidea* and its sub-genera burrow into shell, wood, resin, wax, &c.

Genus *Xylophaga*. This genus bores into floating wood and timbers which are always covered by the sea. Two species are living in Norway, Britain, and South America.

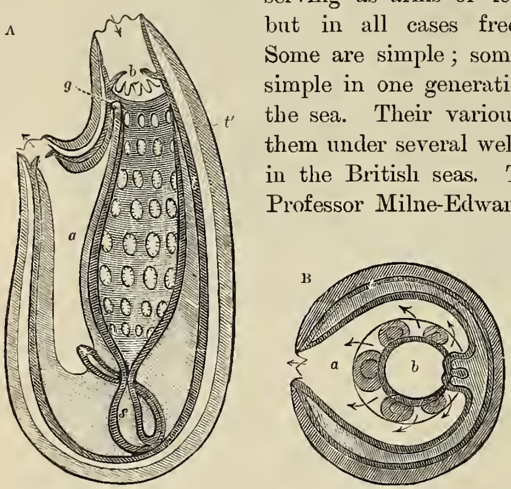
TEREDO NAVALIS.

Genus *Teredo*. The shell is globose, gaping anteriorly, and behind; the valves are trilobate, concentrically striated, divided by a single transverse groove; the hinge margins are inflexed anteriorly; the interior of the valves is furnished with a long, curved process for the attachment of the pedal muscle. *T. navalis* is ordinarily a foot long, sometimes two feet and a half; it destroys soft wood rapidly, and teak and oak do not escape; it always bores in the direction of the grain, unless it meets another *Teredo*. In 1731-2 it did great damage to the piles in Holland, and caused still more alarm; metal sheathing and broad-headed iron nails have been found most effectual in protecting piers and ship-timbers. The *Teredo* was first recognised as a bivalve mollusc by Sellius, who wrote an elaborate treatise on the subject in 1733. (Forbes.) Fourteen species occur living from low water to more than 100 fathoms, in Norway, Britain, and the Tropics.

HENRY WOODWARD.

Structure of the Tunicata Explained—The Throat or Gullet serving as the Breathing Organ—Curious Ebb and Flow of the Blood—Their Division into Simple, Social, and Compound Ascidians—Known to Aristotle—1. SIMPLE ASCIDIANS—Muscular Nature of Tunic—"Sea-Squirts"—Where Found—2. SOCIAL ASCIDIANS—Mode of Union—Genera—3. TRUE COMPOUND ASCIDIANS—Their Anatomy—4. THE PYROSOMIDÆ—Their Pelagic Habits—Their Phosphorescence—5. SALPIDÆ—Pelagic—Solitary or in Chains.

THE Tunicata are enveloped in a coriaceous (or leathery) tunic or mantle; whence their name. This is constructed in the form of a sac with two openings, or else in the shape of a tube of greater or less dimensions, open at both ends. Within the tunic are the viscera, consisting of well-defined organs of respiration, circulation, and digestion, and a muscular and a nervous system. The branchial organ is usually in the form of a sac, placed at the commencement of the alimentary canal, of which it forms, as it were, the ante-chamber, and is never arranged in distinct leaflets, as it is in the leaf-gilled bivalve Mollusca. The circulation of their blood is remarkable on account of its fluctuations and periodical changes of direction. They have no distinct head, and no organs serving as arms or feet. Sometimes they are free, more usually fixed, but in all cases free during the earlier portion of their existence. Some are simple; some present various degrees of combination; some are simple in one generation, combined in another. They are all dwellers in the sea. Their various states and structures enable naturalists to group them under several well-marked tribes, of most of which we have examples in the British seas. The best classification of them is that proposed by Professor Milne-Edwards. He divides them into three sub-orders, of which the *Salpa*, the *Ascidia*, and the *Pyrosoma* are the types, and subdivides the Ascidians proper into simple, social, and compound. Of all, except the *Pyrosoma*, there are British examples.



STRUCTURE OF TUNICATE—A, VERTICAL; B, TRANSVERSE SECTION.

a, the Atrial or Excurrent Chamber; *b*, the Branchial Sac; *s*, the Stomach; *t'*, the Test; *t*, the Muscular Coat or Mantle; the Arrows indicate the direction of the Currents.

"These animals attracted the notice of the all-observing Aristotle. Like most philosophic naturalists, the question of the distinction between the animal and vegetable kingdoms had for him great attractions. The Ascidian was one of the many creatures which he examined, in the hope of gaining definite information respecting such distinction. Its inert and sponge-like form, rooted to the ground, seemed to indicate a vegetable nature; but Aristotle was not content with a mere external survey. He explored its internal structure, and soon perceived its highly animal condition. His description of the Ascidia is wonderfully correct; it occurs in the fourth book of his 'History of Animals.' There he distinctly recognises the Ascidians to be Mollusca, of which he says 'they are the only kind whose whole body is enclosed in a shell, and that shell of a substance between true shell and leather; it may be cut like dry leather.' What comparison could be more graphic or more true? 'They are attached to rocks by their shell. They have two separate openings, which are very small and difficult to notice, one to take in and the other to eject the water. . . . . If we open them, we find a nervous membrane lining this leathery case, and fixed to it at two points corresponding to the openings, one of which may be looked upon as the mouth, the other the vent.' And then he makes further remarks on their anatomy. His appreciation of the nature of the Ascidians is an interesting proof of the wonderful sagacity and minute observation of the great Father of Natural History." (Forbes and Hanley, "British Mollusca.")

FAMILY I.—ASCIDIADÆ (SIMPLE ASCIDIANS).

The body is sac-shaped, gelatinous or leathery, fixed at one extremity and free at the other; it has two more or less prominent orifices, one the "oral," or mouth-opening, the other the "atrial," or excurrent aperture. The simple Ascidians are *not* united into groups by a common integument; but at times

they are met with as gregarious assemblies of individuals, and at others as solitary examples. They are oviparous, and the sexes are united.

On the coasts of the Channel, the Mediterranean, and in the China seas and in Brazil, some of the species of these simple Ascidians are valued as articles of food. "At Cette, *Ascidia* are taken regularly to market, and *Cynthia microcosmus*, although so repulsive externally, furnishes a very delicate morsel much sought after." (Van Beneden.) The young Ascidians commence life as free-swimming, tadpole-like embryo. The tadpole as it appears in the egg is at first an oval disc; a tail is soon after observed; arm-like projections spring from the head of the creature, which then presents a striking analogy with the form of a hydroid Zoophyte; it becomes free, and swims about by means of its rapidly vibrating tail; it fixes itself to rocks and seaweeds by its arms; the tail disappears; that which was the head, or nucleus, sends out root-like projections, orifices appear in it, and its final form as an Ascidian begins to be manifested.

CYNTHIA (ASCIDIA) MICROCOSMUS.

The characters of the genus *Ascidium** are—body sessile, covered with a leathery or gelatinous tunic; branchial orifice eight-lobed; atrial orifice six-lobed; branchial sac not plicated, having a circle inside of simple tentacular filaments; the meshes of respiratory sac papillated.

The leathery sac is exceedingly muscular and contractile, and from the rapidity with which (when touched) they eject the water contained in their bodies, they are popularly known as "Sea-squirts." This outer covering is very remarkable as containing a considerable proportion of a substance apparently identical with cellulose, which is one of the most characteristic of all vegetable products.

The Ascidia are found attached to the under side of rough stones, and vary in length from one to six inches. They are variously, often splendidly, coloured, but are otherwise unattractive. Numbers of them are often found clustering among tangles, like bunches of some strange semi-transparent fruit. (E. Forbes.)

They range from low water to twenty fathoms, attached to rocks, shells, and the like, twenty species being found in Britain, the Mediterranean, Greenland, Spitzbergen, the United States, and elsewhere.

Genus *Molgula.*† The body is attached or free, and more or less globular in form; the orifices are very contractile naked tubes; the oral is six-lobed, the atrial four-lobed. They have been met with between tide-marks in the laminarian zone, and down to a depth of twenty-five fathoms. The surface is membranous, and is usually covered with particles of sand and other extraneous substances. Five species are recorded by Adams, from Britain, Denmark, &c.

Genus *Cynthia.* The body is covered with a coriaceous tunic, not stalked; the oral and atrial orifices are each four-lobed; the branchial sac is longtitudinally plicated. The meshes in the respiratory tissue have no papillæ; there are two ovaries. The species ranges from low water to thirty fathoms. They are frequently found associated in groups of numerous individuals, and their tests, even in the same species, are often variously coloured. They are found on the coast of Greenland, Norway, Britain, and the Mediterranean. They are often gregarious, forming large bunches by the interlacing of their root fibres.

Genus *Pelonaia.*‡ The test is cylindrical; the body elongated, smooth or wrinkled; the apertures are on two small conical eminences, lower end provided with fine rootlets; there are two ovaries. Two species occur in Britain and Norway. Pelonaia resembles *Sipunculus*, one of the worm-like Echinoderms, in appearance; it is not free, but rooted in the mud, and quite as apathetic as other Ascidians.

* Greek, *askos*, a skin bottle. † Greek, *molgos*, a bag of skin. ‡ Greek, *pelos*, mud; *naio*, to inhabit.

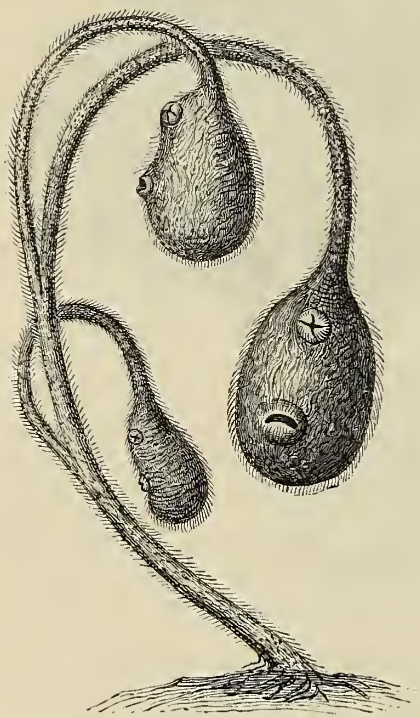
The characters of the genus *Chelyosoma** are—covering horny; form oblong, depressed; upper surface covered by eight polygonal plates; aperture small, six-valved, prominent. Its habitat is Greenland.

Genus *Boltenia.* These Ascidians have a horny covering, and are attached by a stalk, the young growing on the stem of the parent. The apertures are on the side; they live attached to stones in deep water, sometimes as much as seventy fathoms. Six species are enumerated from New Zealand, Greenland, and North America; they are most abundant in Arctic seas.

FAMILY II.—CLAVELLINIDÆ (SOCIAL ASCIDIANS).

The members of this family are compound, *i.e.*, each individual has its own heart, respiratory system, and organs of nutrition, but fixed on stalks or bases common to the group, through which the blood circulates in opposite directions, like the ebbing and flowing of the sea.

Genus *Clavellina.*† The body is elongated, erect; the covering is smooth, transparent, and marked with coloured lines. The individuals of a group are connected or united by creeping tubular prolongations from the common tunic. These are small, transparent, compound Ascidians, found adhering to stones and seaweed by means of curious root-like prolongations of their outer tunic, by which a circulation is kept up common to the entire community. They are found in Great Britain, Greenland, and the Mediterranean.



BOLTENIA (ASCIDIA) PEDUNCULATA.

Genus *Perophora.* The animal is stalked, roundish, flattened, and united by pedicles to creeping root-like tubes, part of the common tunic through which the blood circulates. *P. Listeri* is a minute creature, and was discovered by Mr. Lister at Brighton. He says, "It occurs in groups consisting of several individuals, each having its own heart, respiration, and system of nutrition, but fixed on a peduncle that branches from a common creeping stem, and all being connected by a circulation that extends throughout." Mr. McAndrew and Professor E. Forbes dredged it adhering to weed on the Coast of Anglesey. "It is beautifully transparent, appearing on the weed like little specks of jelly dotted with orange and brown, and linked by a winding silvery thread." (Forbes.)

The characters of the genus *Syntethys* are—animals compound, gelatinous, orbicular, sessile; individuals very prominent; arranged sub-concentrically in the common mass; branchial and atrial orifices simple; not cut into rays.

Syntethys is a *Clavellina* with the habit of a *Diazona.* The only known species forms compact, greenish, translucent, gelatinous masses of half a foot in diameter, and nearly equal height, affixed to rocks or stones by a short base. The individual Ascidians are, when full grown, two inches in length. (Forbes and Hanley.) They are found in Applecross Sound.

FAMILY III.—BOTRYLLIDÆ (TRUE COMPOUND ASCIDIANS).

In the last family the individuals were seen to be connected by a common tunic, but in this family, the *Botryllidæ*, the separate envelopes are fused, and lose their individuality, forming a common covering in which all the Ascidians are imbedded, in one or more groups. Their mouths, or branchial orifices, are simple, and each cluster is ranged round a common "atrial" or excurrent orifice.

If when walking on the sea-shore about low-water mark we turn over large stones, or look under projecting eaves of rock, we are almost sure to see translucent jelly-like masses of various hues of orange, purple, yellow, blue, grey, and green, sometimes nearly uniform in tint, sometimes beautifully variegated, and very frequently pencilled as if with stars of gorgeous device; now encrusting the

* Greek, *chelys*, a tortoise; *soma*, body. † Latin *clavella*, a small staff.

surface of the rock, now depending from it in icicle-like projections. These are compound Ascidians. A tangle or broad-leaved fucus, torn from its rocky bed, or gathered on the sands where the waves have cast it after storms, will show us similar bodies, mostly star-figured, investing their stalks, winding among the intricacies of its roots, or clothing with a glairy coat the expanse of its foliated extremities. If we keep some of these bodies alive in a vessel of sea water, we find them lie there as apathetic as sponges, giving few signs of vitality beyond the slightly pouting out of tube-like membranes around apertures which become visible on their surfaces, though a closer and microscopic examination will show us currents in active motion in the water around those apertures, streams ejected and whirlpools rushing in, indicating that, however torpid the creature may externally appear, all the machinery of life, the respiratory wheels and circulatory pumps, are hard at work in its inmost recesses. In the course of our examination, especially if we cut up the mass, we find that it is not a single animal which lies before us, but a commonwealth of beings, bound together by common and vital ties. Each star is a family, each group of stars a community. Individuals are linked together in systems, systems combined into masses. Each member of the commonwealth has its own peculiar duties, but shares also in operations which relate to the interest and well-being of the mass. Anatomical investigation shows us the details of these curious structures and arrangements, beautiful as wise. Indeed, few bodies among the lower forms of animal life exhibit such exquisite and kaleidoscopic figures as those which we see displayed in combinations of the compound Ascidians.

The merit of first understanding and interpreting the true nature of these curious bodies is due to Jules César Savigny, an illustrious French naturalist, whose zeal in the cause of minute investigation eventually deprived him of sight, and the world of many profound and philosophical researches.

Before Savigny's time the Botryllidæ had been confounded with Polypes, and regarded as forms of the genus *Alcyonium*, to which, indeed, the masses bore a striking resemblance. The earliest distinct figures of these forms appeared in the *Philosophical Transactions* for 1757, where they were published by Schlosser; and in 1758, that curious observer Borlase gave descriptions sufficiently graphic, and rude but unmistakable figures, of several species, in his interesting folio on "The Natural History of Cornwall." The first naturalist who indicated their compound nature, and held forth a clue to their true affinities, was the famous botanist Gaertner, whose zoological observations on marine animals, communicated to and published by Pallas in 1774, are of the highest degree of merit. Gaertner, however, did not follow up his inquiries in these bodies, though to him we owe the generic groups *Botryllus* and *Distomus*. The Italian naturalist, Renieri, in 1793, had a similar obscure perception of their affinities.

The memoirs of Savigny, published in 1816, however, threw entirely new and unanticipated light on their nature. He showed that they were essentially Ascidians, differing from the simple forms only in being united into more or less complicated systems. The researches of Milne-Edwards "On the Compound Ascidians of the Channel," read before the Institute of France, 1839, have fully confirmed those of Savigny, and have also greatly extended our knowledge of these creatures. The figures given by both these naturalists are among the most beautiful and minutely accurate that have ever illustrated and adorned natural history essays. (Forbes).

Genus *Botryllus*. The animals of this genus offer no distinction between thorax and abdomen; their organs of digestion, &c., occupy the thoracic cavity, forming an ovoid mass. The branchial orifices are simple, ranged horizontally round a common cloaca, in groups of simple stars. There are ten species found in the United States and Europe.

Genus *Didemnium*.* The test is coriaceous, polymorphous, sessile and incrusting; the systems numerous, compressed, without central cavities; the individuals are scattered; the abdomen is pedunculate, and the ovary is placed by the side of the intestinal loop. It is found in Europe.

Genus *Eucœlum*.† The test is gelatinous, but in other respects closely resembling *Didemnium*, save that the animals are sometimes arranged in fives (quincuncially). Its distribution is in the European seas.

Genus *Leptoclinum*.‡ The test is thin, gelatinous or coriaceous and incrusting. The individuals are irregularly grouped round common cavities. Six British species are found on roots of Laminaria. The colour is yellowish-white, variegated with blue.

* Greek, *dis*, double; *demnia*, a bed. † Greek, *eu koilos*, much excavated.

‡ Greek, *leptos*, thin; *kline*, a couch.

The characters and distribution of the remaining genera may be succinctly stated.

Genus *Distomus.* Covering semi-cartilaginous, fixed, variable in form, groups numerous, generally circular, orifices six-rayed. Two species are found in Europe, Africa, and Australia.

Genus *Diazona.* Common covering gelatinous, fixed, sometimes stalked, groups prominent, ranged in circles on a concentric disc, like the petals of a flower, with the atrial cavity in the centre ; the branchial orifice is six-rayed. One species occurs in the Mediterranean.

Genus *Polyclinum.** Covering gelatinous or cartilaginous, variable in form, systems numerous, convex, somewhat stellate, tunicaries, groups of individuals ten to one hundred and fifty, at unequal distances. Seven species are known in Britain, the Red Sea, India, &c.

Genus *Aplydium.* Systems numerous, prominent, annular or sub-elliptical, tunicaries three to twenty-five in single rows, equidistant from the centres, branchial orifice six-rayed. Living attached to stones, &c., in deep water They are found in the Red Sea and Europe.

Genus *Sidnyum.* The animals of *Sidnyum* partake of the characters of *Synœcium* and *Aplydium,* resembling the former in the structure of their stomach, and the latter in their branchial apparatus. Each has an eight-toothed branchial orifice, and a simple tubular vent folded against the thorax. The ovary is pedunculated and very conspicuous at the extremity of the animal. (Adams.)

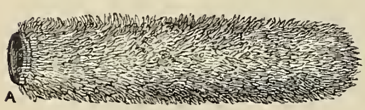
Genus *Synœcium.* Semi-cartilaginous, cylindrical, stalked, solitary or gregarious, systems circular, terminal tunicaries six to nine in a group ; apertures six-rayed. Only one species is known from the Arctic seas.

Genus *Sigillina.* Covering solid, gelatinous, conical, elongated, erect on a stalk, individuals in irregular circles one above another, openings six-rayed. A single species is found living in tropical seas.

FAMILY IV.—PYROSOMIDÆ.

The animals are compound, free and pelagic.

Genus *Pyrosoma.*† The body is cylindrical, hollow, non-contractile, cartilaginous, open at one end only, and covered externally by the numerous pointed zooids, arranged in whorls ; the interior is mamillated and pierced by the excurrent orifices of the tunicaries. The pyrosomes are from two to fourteen inches long, and from half an inch to three inches in circumference. They are made up of innumerable individuals united side by side. The inhalent openings are external, the exhalent within the tube, and the result of so many little currents discharged into the cavity is to produce one general outflow, which impels the floating cylinder, with its closed end forward, through the water.



PYROSOMA.
A, the atrial or excurrent opening.

June 15th, 1850, lat. 45° S., long. 110° W. :—" The sky was clear but moonless, and the sea calm, and a more beautiful sight can hardly be imagined than that presented from the decks of the ship as she drifted, hour after hour, through this shoal of miniature pillars of fire gleaming out of the dark sea, with an ever-waning, ever-brightening, soft bluish light, as far as the eye could reach on every side. The *Pyrosoma* floated deep, and it was with difficulty that some were procured for examination and placed in a bucketful of water. The phosphorescence was intermittent, periods of darkness alternating with periods of brilliancy. The light commenced in one spot, apparently on the body of the zooid, and gradually spread from this to the centre in all directions ; then the whole was lighted up. It remained brilliant for a few seconds, and then gradually faded and died away, until the whole mass was dark again." (Huxley, *Philosophical Transactions,* Part II., 1851, p. 580.)

M. Péron first observed the phosphorescence of the Pyrosomes in a squall at sea. He says :— " Suddenly we discovered at some distance a great phosphorescent band stretched across the waves and occupying an immense tract in advance of the ship. Soon we reached the illuminated tract, and perceived that the prodigious brightness was certainly and only attributable to the presence of an innumerable multitude of animals floating on the waves. Those seen near the surface of the water perfectly resembled small incandescent cylinders of iron."

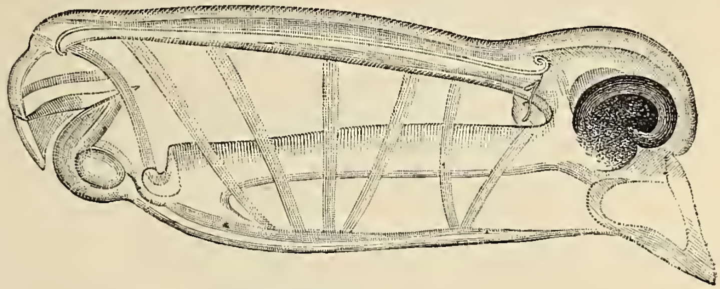
FAMILY V.—SALPIDÆ.

The animals are free, oceanic, alternately solid, and united in circular or lengthened groups. These Salpa chains vary in length from a few inches to many feet, and swim through the water with a

* Greek, *polys,* many ; *kline,* a couch.

† Greek, *pyros,* fire ; *soma,* a body.

regular serpentine movement; but when taken from the water the individuals of the group are easily detached. Chamisso discovered that the solitary *Salpæ* do not belong to species distinct from those united in chains, however dissimilar, but are either the parents or the progeny, as the case may be, of the aggregated forms; and that chained *Salpæ* do not produce chained *Salpæ*, but solitary *Salpæ*, which in turn do not produce solitary but chained *Salpæ*, "so that a stepmother is not like its daughter or its mother, but resembles its sister, its granddaughter, and its grandmother." (Chamisso.)



SALPA MAXIMA (*magnified*).

In the genus *Salpa** the animal is sub-cylindrical, being truncated in front by the mouth-opening, and pointed behind; the excurrent or anal orifice is placed beneath the pointed termination; the body-covering is thin and transparent; the muscular mantle is incomplete, forming transverse or oblique bands; the mantle cavity is lined with a series of sinuses, or folds; the gill is rudimentary, forming an oblique band across the interior; the visceral cavity is behind. The young are produced by gemmation in chains, consisting of individuals unlike the parent, and becoming oviparous, the alternate generations only being alike.

"The individual Salpians are from half an inch to ten inches in length; the chains vary from a few inches to many feet, but are often broken up, indeed the adults appear to be always separate. They swim with either end foremost, although the pointed end would seem the normal one, as the motion is produced by the forcible expulsion of water from the mantle. Each orifice is furnished with a valve, and there is no division between the atrium and respiratory cavity except the rudimentary gills, or 'hypopharyngeal band.' The Salpa-chains also swim with a regular serpentine movement.

"The solitary Salpæ always contain a chain of embryos winding spirally round the visceral nucleus. "The aggregate Salpæ produce a single ovum at a time, which is attached by a pedicle to the posterior part of the respiratory cavity." (Huxley.)

Genus *Doliolum*.† The body is transparent, cask-shaped, open at the ends, and from two to ten lines in length; the oral extremity is rather prominent, with twelve denticulations; the posterior end is fringed. (Huxley.) There are two species known. They are found near Amboyna, Vanicoro, and New Zealand.

In *Appendicularia*‡ the body is ovoid, one-sixth to one-quarter of an inch long, with a long curved lanceolate tail, or swimming organ; the smaller end is perforated, leading into a cavity lined by a system of folds; the pharynx, which is ciliated, serves in lieu of a gill; the gullet is short, curved; the stomach is wide. (Huxley.)

These minute creatures appear to be the lowest forms of the Tunicata, typifying, in their adult stage, the larval state of the higher Ascidians.

"When cruising," says Prof. Edward Forbes, "off the north coast of Scotland, in 1845, with Mr. Robert McAndrew, our attention was attracted by the appearance of cloudy patches of red colouring matter in the water, and on procuring a sample, and submitting it to microscopic examination, it was found to consist entirely of the curious and anomalous creatures known as *Appendicularia*." Dr. S. P. Woodward writes:—"Many small *Appendicularia* were taken in the towing net (May, 1857) in the Channel, between Portland Bay and Ushant."

* Greek, *salpe*, a sea-fish. † Latin, diminutive of *dolium*, a large jar.
‡ Lat., *Appendicula*, a small appendage.

Henry Woodward.

THE INTERMEDIATE GROUP, MOLLUSCOIDA.

THE MANTLE-BREATHING BIVALVES (BRACHIOPODA) AND THE MOSS-ANIMALS * (BRYOZOA).

THE BRACHIOPODA—Life History and Characters of the Brachiopoda—Origin of the Name—Subdivision of the Group—Its Relations to other Organisms—Growth and Structure of the External and Internal Skeleton—Muscles—Organ of Attachment—Mantle—Gills—Digestive, Generative, and Nervous Systems—How the Brachiopoda Live—Classification and Anatomy of Minor Groups—Distribution in Space and Ranges of Depth of Living Forms—Fossil Genera—Embryology and Affinities—THE BRYOZOA*—Life History of the Moss-animals—Name and Position of the Group—Its Chief Subdivisions—The Colonial Skeleton—The Individual Moss-animal—Muscles and their Action—Respiratory, Circulatory, and Reproductive Systems—Structure and Functions of the Appendicular Organs—Classification and Anatomy of Minor Groups—Geographical and Bathymetrical Distribution of Marine and Fresh-water Genera—Geological Range—Reproduction of the Colony and of the Individual—Embryological History—Affinities and Systematic Position of the Brachiopoda and Bryozoa.

ALL the Brachiopoda,† or mantle-breathing bivalves, are exclusively inhabitants of the ocean. They are found attached to stones, rocks, corals, sponges, sea-mats, and sea-weeds, or adhering to each other in masses, in shallow water, and are dredged from considerable depths. The class—a very extensive one—comprises about one hundred and thirty genera, and between four and five thousand species. By far the greater number of these are extinct forms; but the one hundred and thirty existing species merit consideration as the surviving members of a most ancient but now declining race. For these lowly molluscs were among the first representatives of life in the ancient seas of our planet, during remote geological ages.

The first figures and descriptions of members of this group were given by Prince Fabio Colonna in 1606. But the animals were for many years confounded with the "plaited-gilled" bivalves (Lamellibranchiata) already described, and the great Cuvier was the first to recognise their distinctive characters. He constituted a separate class for the reception of the Brachiopoda, signifying "arm-footed," under the impression that some largely-developed internal organs which occupy the greater portion of the interior of the shell—the so-called "arms" or "feet," which are the special characteristic of these organisms—were used as feet, and employed in the processes of locomotion. It is now known that these organs, although capable of protrusion, in some genera, beyond the marginal or outer edges of the shell, are never really used for locomotion. De Blainville's subsequently proposed title of "mantle-breathers,"‡ referring to the respiratory function exercised by the pallium or mantle—the delicate membranous internal lining of the shell—is therefore used by some naturalists. But the first name enjoys the right of priority and long habit, and as Brachiopoda these animals will probably ever be better known, although they never walk upon their so-called arms or feet.

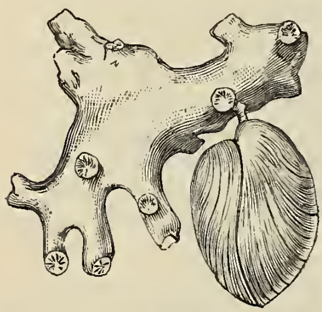


Fig. 1.—TEREBRATULA CUBENSIS ATTACHED TO CORAL AT A DEPTH OF 420 FATHOMS, OFF ASCENSION. (*After Davidson.*) ("*Challenger*" *Expedition.*)

In fact, their powers of locomotion are somewhat limited, being restricted, in most genera, to a free movement on the muscular stalk or peduncle. Members of one genus, however, jerk themselves about by the sliding action of their valves, swinging the fringes of setæ, or minute bristles edging the mantle, to and fro like the oars of a galley, and leaving a peculiar track in the sand. Young individuals, in the earlier stages of growth, are quite free and unattached, swimming actively about in the water. Others were fixed during a portion of their lives, the opening for the peduncle subsequently becoming closed. A few of the fossil forms show no marks of attachment, and are believed to have always enjoyed a free existence.

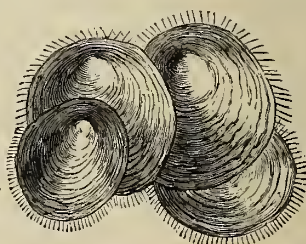


Fig. 2.—DISCINA LAMELLOSA. OFF CALLAO, PERU. (*After Davidson.*)

The Brachiopoda were also called Lampades, or lamp-shells, by the older naturalists, the shape of the shell, and the hole serving for the passage of the peduncle, suggest-

* Greek, *bruon*, moss; *zoon*, an animal. † Greek *brachion*, an arm; *pous*, the foot.
‡ Palliobranchiata, Lat., *pallium*, a mantle; Greek, *branchia*, gills.

ing this comparison with an Etruscan lamp. It is one, however, that is applicable to comparatively few species. At one time these organisms were ranked with the higher shell-fish—after the Gasteropoda—thus taking precedence of all the bivalve class. But they were not long allowed to maintain this position; first reduced to a lower grade, they were afterwards ejected from the ranks of the shell-fish proper, and relegated to an inferior division of the molluscan type to which the name of "mollusc-like animals"* was applied. Some recent authorities assign them a very different position, and after detailed observations of the successive stages of development assumed by the immature animals, place them with a section of the worm family (Annelida), that surround themselves with a tubicolar sand-covering, a habit, by the way, which is shared by one family of the Brachiopoda. But the adult animal of all the mantle-breathing bivalves is always enclosed between, and protected by, an external shell forming two valves or pieces, which are generally regarded as "front" and "back" shields, instead of right and left, as in the bivalve shells (p. 230). Each of the two pieces composing the shell is always symmetrical in itself, but the shell is never "equivalve," as one piece is invariably larger than the other. Yet the expanded edges are nearly always level and opposable, resting one upon the other.

None of the recent Brachiopoda are very large, but many of the extinct forms attained considerable dimensions, and in one carboniferous species (*Productus giganteus*) the shell sometimes measured over a foot in length and in breadth. The shells of many species are quite smooth, or striated and marked with circular lines of growth; others are coarsely or finely ribbed with longitudinal or transverse ridges, or depressions. Some are white and of a transparent and glassy texture, as in the deep sea forms. Those inhabiting Arctic or Northern seas are of a dull grey colour, and the shell is more robust; while the tropical species are often brilliantly coloured, the prevailing hues being crimson, yellow, emerald green, brown, or bluish black. Traces of coloration are occasionally preserved in fossil specimens, many of which are beautifully sculptured externally, and some extinct forms were additionally ornamented with long and elegant spines, attached to the outer surface of their shells. In some genera the spines covered the whole exterior, and were coloured like the shell, as in the *Rhynchonella spinosa*† (A) of the Oolitic seas, or long and slender, were irregularly distributed over the surface of the ventral valve (B). In others they were merely developed in the region of the hinge (C). The spines, in one instance, armed with minute hooklets, were often four or five times the length of the shell. They were generally tubular, sometimes with a double chamber like a gun. (Davidson.) Opinions have varied considerably with regard to the functions of these appendages. Some writers consider them merely ornamental, others, as canals admitting the sea-water to the interior of the shell, or as organs of attachment which served as anchors to moor the animal at the bottom of the sea. A tiny species that flourished in the Carboniferous seas, though a silent witness, furnishes irrefutable evidence that they occasionally acted as clasping organs. Fig. 3, D, represents this small "embracing" Productus, encircling the stalk of a sea lily (crinoid), with its slender spines. Thus the animal, enabled to resist the rude buffets of the waves, was preserved from rough contact with surrounding objects.‡

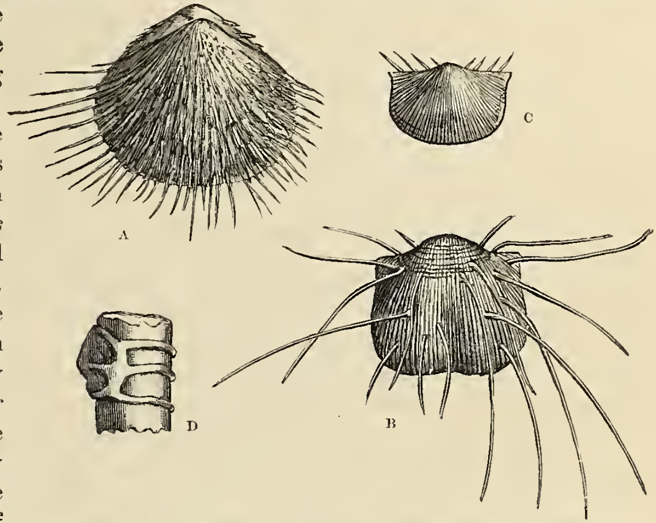


Fig. 3.—A, RHYNCHONELLA SPINOSA, INFERIOR OOLITE; B, PRODUCTUS LONGISPINUS CARBONIFEROUS; C, CHONETES; D, VENTRAL VALVE OF PRODUCTUS COMPLECTENS, LOWER CARBONIFEROUS LIMESTONE. (*After Davidson and R. Etheridge, Junior.*)

The Brachiopoda are subdivided into two principal groups. All members of the first

* The Molluscoida of Milne-Edwards. † Spiny little beak.

‡ Robert Etheridge, Junior, F.G.S., *Quarterly Journal of the Geological Society*, 1876.

and more highly organised division of Tretenterata,* are characterised by the presence of an anal orifice. Those belonging to the second and lower group of Clistenterata† are not provided with that opening, and the intestinal tube ends in a blind sac. These important distinctive characters, first made known by the anatomical researches of Messrs. Hancock and Huxley, have since been confirmed by Professor Morse in a living Clistenterate. He witnessed the rejection of the waste products by the mouth, the only outlet in one of the lower forms (Terebratulina). Other remarkable structural differences are associated with these distinguishing features. The first, or Tretenterate group, is devoid of any internal skeleton, the two valves of the shell being quite free, and kept in place solely by the shell muscles. In at least one genus of it (Lingula), they move freely from side to side, opening obliquely by means of the strong "lateral" or side muscles, specially restricted to that purpose (Fig. 6, *j k l*). Members of the second group generally have the two valves firmly united by hinge teeth, which fit into sockets in the opposite valve and effectually prevent any lateral movements. Consequently, the side muscles are not developed, but are replaced by others which enable the animal to open its shell a very little way in a horizontal direction; or, in one genus (Thecidium) at right angles. But the gape is exceedingly small amongst the Brachiopoda, as compared with that of the true bivalved mollusca. An internal skeleton, for the support of the breathing organs, is usually present in the Clistenterata, and the shape it assumes is most variable. As the Tretenterates appeared first on the globe, the second and inferior forms may be regarded as possibly their degenerated descendants. Members of one ancient and extinct family,‡ believed to be exclusively restricted to the seas of the Silurian age, present a general external resemblance to the lower and Clistenterate species. They appear also to have possessed some characters of both groups, rudimentary hinge teeth, indicating interlocking valves, being associated with the impressions left by side muscles which may have enabled the animal to move its shell sideways. The chemical constituents of these often massive shells are also of a different and somewhat intermediate nature, carbonate of lime entering far more largely into their structure than into that of Lingula and Discina, which are almost exclusively composed of a corneous or horny substance; while in the shells of Crania, Glottidia, and all the Clistenterata genera the calcareous element predominates.

The shell is secreted by the mantle, and appears (in Terebratulina) in the fifth stage of the development of the hitherto naked embryo. It first develops in the region of the peduncle, subsequently increasing in growth at the margins of the valves, and it differs so considerably, both in structure and mode of growth, from that of the lamellibranch, that a small fragment can be readily identified by microscopic examination, even when derived from a fossil species. Dr. Carpenter describes the shell as consisting of two layers which correspond in thickness with the outer layer only of that of the lamellibranch. It has a fibrous prismatic structure which gives it a scale-like appearance (Fig. 4, A). In many genera the shell is perforated with minute canals, differing in size and situated at variable distances from each other. They make their appearance in the earliest stages of the development of the shell; the largest measure $\frac{1}{300}$ and the smallest $\frac{1}{3000}$ of an inch in diameter. These canals are charged with cellular projections (Fig. 4, B, C) of the fleshy mantle, corresponding in position with tiny cells spread over the upper surface of this delicate membranous covering of the animal. Their functions are not absolutely determined, but Dr. Carpenter believes them to be subservient to respiration.

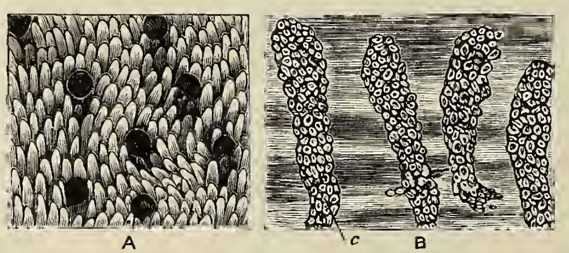


Fig. 4.—SECTIONS OF SHELL STRUCTURE. C, CÆCAL TUBULI OR PROJECTIONS. (*After Carpenter.*)

Of the two valves composing the shell, the front or ventral valve (Fig. 5, A) is generally the larger. In many forms it is produced at the apex (*á*) into a prominent beak perforated at its extremity by a hole, the foramen (*f*), for the passage of the peduncle or bundle of muscular fibres by means of which the animal attaches itself to neighbouring objects. The back shield, or dorsal valve (Fig. 5, B), contains the animal, and also a variously-shaped

* Greek, *tretos*, perforated. † Greek, *cleistos*, shut; *entera*, intestines. ‡ The Trimerellidæ.

process, the loop (*l*), which forms the internal skeleton and support of the more or less developed brachial or breathing organs, "the arms." This delicate calcareous appendage—formed of the same substance as the outside shell—in reality consists of slender prolongations of the shell lip. It varies considerably in size, shape, and method of attachment to the interior of the dorsal valve, and is specially characteristic of the inferior or Clistenterate group. The valves are firmly attached to each other by two curved hinge-teeth (A, *t*), which fit into corresponding depressions or sockets in the opposite dorsal valve (B, *s*) in the articulated species. When thus secured the united valves cannot be easily detached, but they are opened readily by the action of the shell-muscles, five pairs of which are developed for that purpose (Hancock). Two pairs, the adductors *a*, close the valves. Another pair, divaricators, open them, *c*, *c*′, and two others, the ventral adjustors *b*, and the peduncular *b*′, adjust the shell upon the peduncle.

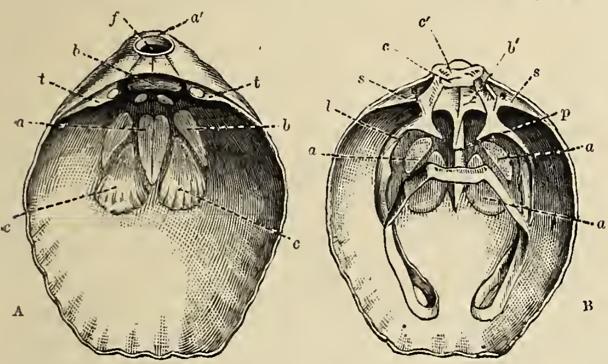


Fig. 5.—A, VENTRAL; B, DORSAL VALVE OF WALDHEIMIA AUSTRALIS, SHOWING SCARS OF MUSCULAR ATTACHMENTS. (*After Davidson.*)

a′, apex; *f*, foramen; *p*, septum; *t*, teeth; *s*. sockets; *l*, loop; *a*, adductor; *cc*, divaricator; *b*, ventral adjustor: *b*′, peduncular muscles.

Among the higher or Tretenterate group the muscular system is very complicated, and in the Discinidæ (Fig. 2) approaches nearest to that of the articulated genera. In the helmet shells (Craniadæ, Fig. 9) the valves move upon the straight side, as on a hinge without sliding, but in Lingula, (Fig. 7) they have been observed to slide from side to side. This genus has five pairs of muscles, and an odd one, their functions being thus apportioned:—The single muscle in the region of the beak, the umbonal (Fig. 6, *g*) opens the valves. The pair of centrals (*h*) close them; three pairs of laterals (*j*, *k*, *l*) are restricted to the sides of the valves, and slide them; while the fifth pair of transmedians (*i*) controls the movements from side to side of the beak or umbonal regions of the shell. (King.) There are no peduncular muscles. The muscles leave definite, arched, crescent, or otherwise shaped, impressions on the interior of the valves at the points of their attachment to the shell. These scars, recognisable even in many fossil forms, serve as additional clues in referring a genus to one or other of the particular family groups.

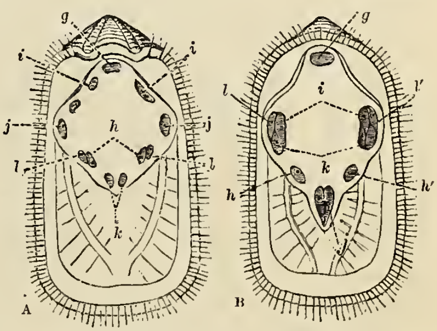


Fig. 6.—A, VENTRAL; B, DORSAL VALVE OF LINGULA ANATINA. (*After King.*)

g, Umbonal Muscles; *h*, Centrals; *j*, *k*, *l*, Laterals *i*, Transmedians.

The peduncle of the Tretenterates passes either through a fissure in the ventral valve, as in Discina (Fig. 2), or between the beaks of the almost equivalved shell, as in Lingula (Fig. 7), in which this mooring organ is sometimes enormously developed, occasionally measuring over nine inches. It is mobile, ringed,* highly contractile, and composed of an outer horny layer, and an inner one of longitudinal muscular fibres. It is hollow, and the blood, which is of a red colour, courses back and forth in the central cavity, circulating for several days after death and separation from the thoracic portion of the animal. Its surface is crowded with minute pores, and in two species (*Lingula pyramidata* and *L. anatina*), which live free in the sand, and do not adhere by its extremity, has the power of agglutinating a sand-tube. This is promptly repaired when broken or removed from the animal, an operation thus described by Professor E. S. Morse. "When the peduncle was broken off, a bulb of sand would soon be agglutinated to protect the broken end, and not only sand was used, but bits of seaweed; and in one case a little stick was incorporated in this structure. I brought home with me to Salem, Mass., a number of living specimens, and these were kept alive in large bowls, from

* According to the researches of W. K. Brooks ("Results of the Chesapeake Laboratory, Baltimore, 1879"), the segmentation of the peduncle in Lingula described by Morse is not a permanent character.

June to October, by imitating as far as possible their natural surroundings. They would often protrude above the surface of the sand, and instantly jerk back when alarmed. On emptying the sand from the bowl one day, great was my surprise to find that all of the Lingulæ had covered the bottom of the bowl with large irregular sand-tubes, cemented to the sides and bottom of the dish, the tubes running over each other, and presenting precisely the appearance as that produced by Terabella and allied forms when kept in dishes in this way." The peduncle is sometimes preserved in a fossil state.

The interior of each valve of the shell is invariably lined by the pallium or mantle, a delicate membrane which closely invests the body of the animal occupant. It is divided into two lobes, which are united only at the peduncle and extend to the outer edges of the shell, where they are fringed with bristles (Fig. 7, *s*) of variable thickness, and length. The mantle is composed of two distinct layers: the outer adheres closely to the valves of those genera in which the shell substance is perforated by canals which are partially filled with its minute projections. The under layer, of a thinner, granulated texture, is clothed with vibratile cilia. The mantle secretes, nourishes, and repairs the shell substance, and is also concerned with the processes of respiration, the purification and circulation of the blood. It also serves in some cases as a medium for the discharge of the eggs, which apparently accumulate in the larger sinuses of its arterial system. In some genera, a series of very minute calcareous plates stiffen the mantle and form a protection over the veins, the breathing organs, and *the perivisceral cavity*—as that small portion of the shell which is occupied by the digestive organs is termed, to distinguish it from the larger space—*the pallial chamber*—filled by the mantle. This—separated from the former by a membranous wall clothed with cilia—contains only the brachial organs and mantle, and may be compared with the tentacular sheath of the Moss-animal. (See p. 273.)

Fig. 7.—LINGULA PYRAMIDATA. (*After Morse.*)
p, Peduncle; *t*, its Terminal end encased in Sand tube; *s*, Setæ or Bristles.

The largely-developed fleshy brachial organs, so characteristic of the Brachiopoda, occupy a considerable portion of the pallial cavity of the shell. Formerly regarded as uniting the functions of respiration and locomotion, they gave the name of Brachiopoda to the group. But they are more correctly designated the brachial appendages. They are often supported by the calcified loop-shaped prolongations of the shell lip already alluded to (Fig. 5, B, *l*). They are now known to act as accessory breathing and circulatory organs, and are also employed in collecting and directing towards the mouth situated at their base currents of water; and in eliminating therefrom the microscopic organisms, consisting chiefly of minute plants, diatomaceæ and infusorian animalcules which constitute the nourishment of the animal inhabiting the shell. Hancock describes these organs as consisting of a flexible membranous tube, fringed on one side by a double row of hollow tentacles or cirri (Fig. 8, *i*). Each of these is capable of separate movement, and is in turn clothed with pliant hairs or cilia. These cilia draw the "minute nutrient particles" down into the groove or gutter which lies at the base of the tube, which is also lined with cilia, and so the nourishment is conveyed down its course to the mouth situated at the origin of the arms. This opening—a simple slit—communicates with a comparatively short gullet, which leads into a more elongated stomach. The alimentary canal, of variable length, ends somewhat abruptly in a blind sac in the lower forms. In the higher, it is prolonged, turns upwards, and terminates in an anal orifice (*g*) between the right edges of the mantle nearest the dorsal valve.

The liver (Fig. 8, *r*)—of a greenish colour and very large—is divided into two lobes, respectively situated on either side of the alimentary canal. It communicates by two or three short ducts with the stomach, and in the higher forms is flanked by the large-sized genital organs of either sex. Among the Clistenterates the generative products—developed and set free in the perivisceral cavity—are conveyed through trumpet-shaped and ciliated ducts into the pallial chamber, thence gaining access to the sea-water. The pallial blood-channels lie between the two layers composing the mantle. A series of canals running one into the other, and presumed to be vascular, permeate the membranous

lining of the perivisceral space, as well as the investing ovarian membranes, but the details of the very rudimentary circulatory system of the Brachiopoda are imperfectly known. Some of the Brachiopoda were formerly credited with the possession of two or even four pulsating organs. But the so-called "hearts" of Cuvier and Owen are now known to be connected with the oviducts; while the "pyriform vesicle" (*y*) of Hancock and Huxley has proved to be non-contractile, without muscular walls, and to have no connection with the arterial system. Semper has demonstrated the non-existence of a heart in Lingula, and Morse has more recently maintained that the circulation of the blood is entirely due to "ciliary action." Thus the presence of the pliant, hair-like cilia, so often referred to as present on the mantle, the lining of the body cavity, the cirri of the arms, and in the tube at their base, acquires additional significance, for by their exclusive agency the blood is distributed through the complicated vascular system; while the function of aëration, generally effected by the gills—the equivalents of the lungs of other animals—is among these lowly molluscs, divided between the mantle and the "arms," a fact that illustrates the imperfections of the Brachiopodal organisation, and their lowly rank in the molluscan type.

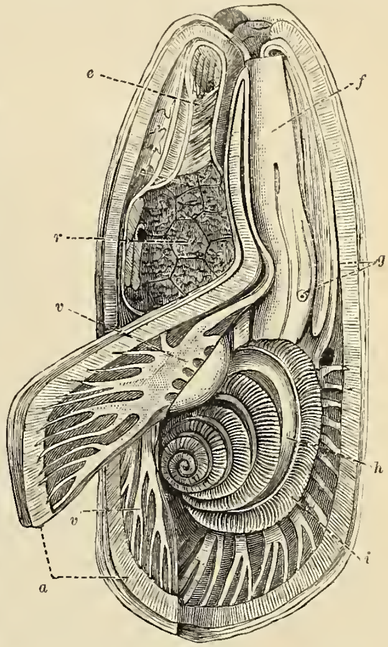


Fig. 8.—ANIMAL OF LINGULA ANATINA, ENLARGED. (*After Hancock.*)

a, Dorsal Lobe of Mantle; *v*, Vascular System; *h*, Brachial Organs; *i*, Cirri; *f*, Perivisceral Cavity; *p*, Pallial Chamber; *e*, Intestine; *g*, Anus; *r*, Liver; *l*, Lateral Muscles.

The nervous system is composed of two nerve-centres, united by a nerve, forming a collar round the gullet, and communicating by a series of minute fibres with the arms, the mantle, and pseudo hearts—the oviducts. Being headless, or acephalous, the Brachiopoda have no brain. But Professor Morse has detected the presence of a rudimentary organ of hearing in Lingula. Eye-spots are developed in all the embryos, but disappear in the later stages of growth. Yet the adult animals are sensitive to light; and although possessing neither well-developed foot, head, eyes, heart, nor one localised breathing organ, exhibit a certain amount of activity and intelligence in fulfilling all the necessary purposes of their existence. The following description has been given by Professor Morse of the mode of life of a youthful individual of the genus Terebratulina:—"The animal whirled quickly on its peduncle. When at rest the valves were always closed, and rested on the rock. From this position it turned slowly more than half-way round, raising the body at the same time almost erect. This movement being completed, the valves would very slowly open, and the cirri expand as if to perform a grasping motion; in no case, however, were they projected beyond the margins of the valves. The cilia lining the cirri produced gentle currents in the water. In this position, with the valves widely open and cirri expanded, the animal would remain motionless for twenty or thirty seconds, and then, with an abrupt closing of the valves, suddenly assume its first position. In watching these motions for a long time, one could not help being impressed with the fact that caution was evidently indicated in the slow and careful movements made in elevating and opening the shell; while the prompt closing of the valves, and the alert manner in which the animal regained its first position, seemed to show that food had been secured, and further caution was unnecessary."

Nearly all the Brachiopoda can be referred to one or other of the two great groups into which the class has with common consent been divided, a separation based upon the important structural differences already detailed, which are epitomised in the names Tretenterata and Clistenterata respectively, applied by Prof. William King. The primary groups are again subdivided into eleven families or assemblages of allied forms, each of which may contain either one or several genera and sub-genera. In accordance with the system elaborated by Mr. Thomas Davidson, in his numerous memoirs on British and Foreign Fossil Brachiopoda, these minor classificatory relationships are connected with the chief structural peculiarities of the animal—the fleshy breathing organs—their nature and shape differing considerably in those forms in which the internal skeleton is absent, or only slightly developed, and depending upon its variable modifications when present. The supporting

calcareous labial appendages (Figs. 5, B, 12, *l*) are therefore one of the most important features affecting the life and organisation of the animal inhabiting the shell, and their value as classificatory agents is apparent. Frequently preserved in a fossil state, there can be no doubt that they afford the simplest and readiest mode of determining the true relationship of one adult form of Brachiopod to another, and one that is infinitely preferable to the purely external characters of these very variable shells. In the subjoined table of families, typical genera are placed first, and those represented solely by extinct forms are printed in italics :—

	Family.	*Genera.*
ORDER TRETENTERATA	LINGULIDÆ	Lingula, Glottidia, *Lingulops, Obolus.*
	DISCINIDÆ	Discina, Discinisca, *Trematis, Siphonotreta.*
	CRANIADÆ	Crania, *Craniops, Craniscus.*
	Trimerellidæ	*Trimerella, Monomorella, Dinobolus.*
,, CLISTENTERATA	*Productidæ*	*Productus, Chonetes, Strophalosia.*
	Strophomenidæ	*Strophomena, Orthis, Leptæna.*
	Pentameridæ	*Pentamerus, Stricklandina.*
	Spiriferidæ	*Spirifer, Spiriferina, Meristella, Athyris.*
	RHYNCHONELLIDÆ	Rhynchonella, *Rhynchopora, Atrypa.*
	TEREBRATULIDÆ	Terebratula, Waldheimia, Argiope, Laqueus, *Kingena.*
	THECIDIDÆ	Thecidium.

ORDER TRETENTERATA.

FAMILY, THE LINGULIDÆ.*

The typical genus Lingula, one of the most ancient and persistent of Brachiopoda, is, as might be expected, a very hardy animal. The hingeless valves of the usually green or dusky brown shells are nearly equal in size, and it is from their elongated or tongue-like shape that the family name is derived (Fig. 7). The thick fleshy breathing organs with inwardly-directed spires are unsupported by any elaborate calcified process, but merely strengthened by a simple longitudinal plate or septum, rising from the centre of the dorsal valve. Professor Morse describes the American and Japanese species as living free and partially buried in sand, and further states that "the anterior borders of the mantle contract in such a way as to leave three large oval openings, one in the centre and one on each side. The bristles, which are quite long in this region of the animal, so arrange themselves as to continue these openings into funnels, and entangle the mucus escaping from the animal. A continual current is seen passing down the side funnel and escaping by the central one." They bury themselves quickly in the sand, and the lengthy and worm-like peduncle agglutinates a sand-tube.

THE DISCINIDÆ.

This venerable family is represented by the long-lived genus Discina in the existing oceans. The two horny unarticulated valves are circular or disc-like, hence the name. The upper, resembling that of a limpet, is smooth with an almost central apex. The lower is perforated for the passage of the short plug, or byssus, by means of which they adhere to each other (Fig. 2). No external skeleton is developed for the support of the breathing organs, which curve backwards, and end in small spires directed downwards. Very little is known of the habits of the living species which, widely distributed, exist both in shallow water and at very considerable depths.

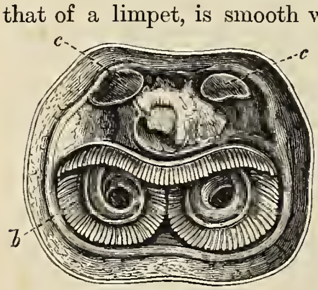
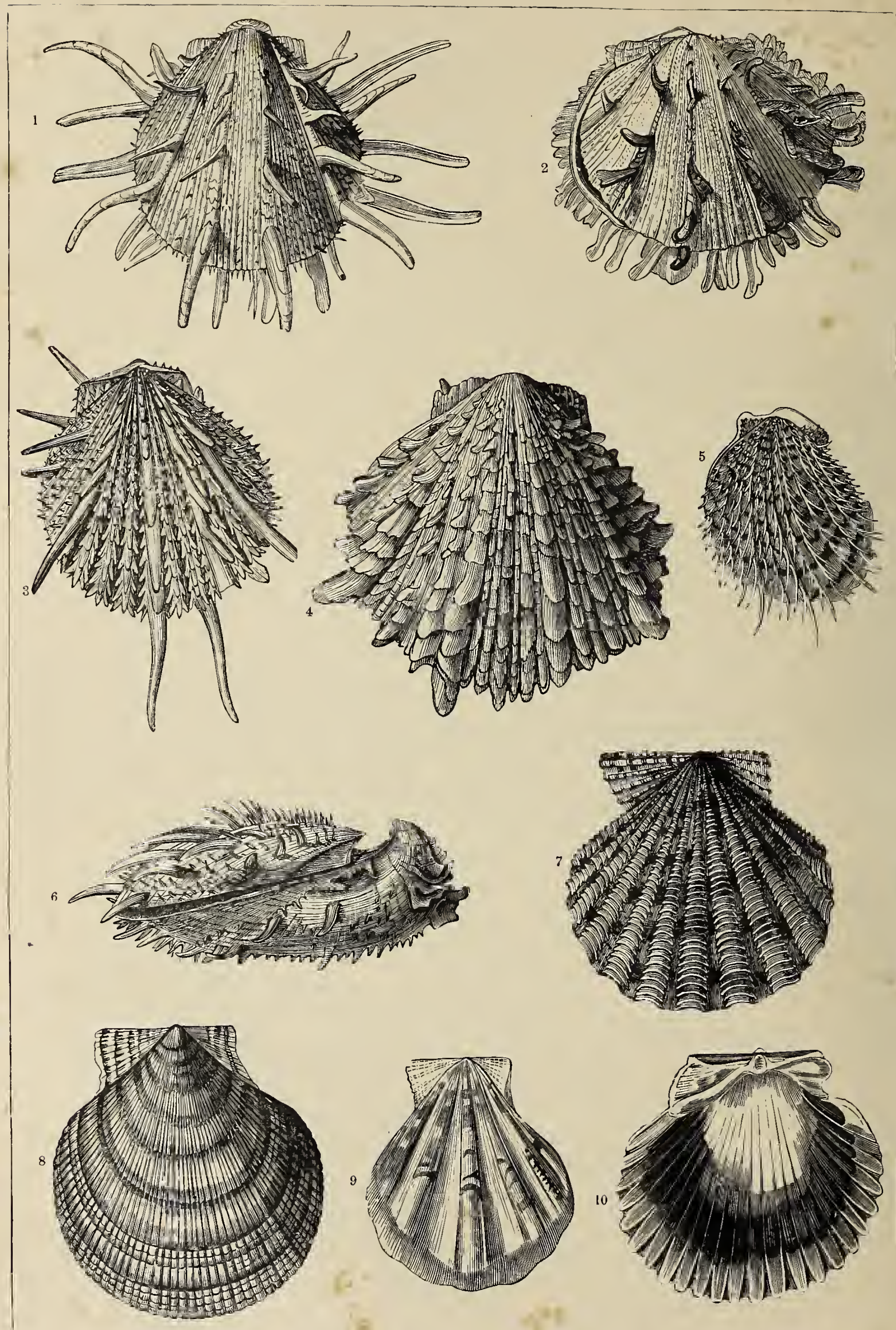


Fig. 9.—CRANIA ANOMALA. (*After Davidson.*)
b, Brachial Organs; *c*, Two Muscular Impressions.

THE HELMET-SHELLS.

The Craniadæ† attach themselves by the flat or under valve to other bodies. The helmet-shaped appearance of the upper valve gives the name to the group. On the interior of the thick and hingeless calcareous shell four distinct muscular impressions are visible. The arms (Fig. 9, *b*) are free, coiled in spirals towards the concave space of the dorsal valve, which is generally firmly attached to foreign objects. The two valves are only united by muscles, and separate readily on the death of the animal, hence the large number of single valves occurring in a fossil state. They range in time upwards from the Silurian epoch.

* Latin, *lingula*, a little tongue. † Greek, *kranos*, a helmet.



SHELLS OF PECTEN AND SPONDYLUS.

1, Spondylus regius; 2, S. gæderopus; 3, S. imperialis; 4, S. crassisquama; 5, S. radians; 6, S. avicularis; 7, Pecten pallium; 8, P. Islandicus; 9, P. plica; 10, P. purpuratus.

THE TRIMERELLIDÆ.

The four genera comprised in this family, all apparently restricted to the Silurian seas, occur abundantly in rocks of that age in Sweden, Russia, and Canada. The shell, generally calcareous and often extremely massive, was characterised by a raised and vaulted platform for the attachment of the muscles. The animal was probably Tretenterate, as no support for the brachial organs is preserved. But the occasional presence of rudimentary hinge-teeth and characters of the muscular system indicate that the structure of these extinct forms was somewhat intermediate between that of the Tretenterate and Clistenterate group.

ORDER CLISTENTERATA.

FAMILY, THE PRODUCTIDÆ.*

This family ranges in time from the Silurian to the Permian epoch. It includes a number of fossil forms, which vary considerably among themselves. The prominence of the beak and shoulder of the shell suggests the generic name of the type (Fig. 3, B, C). The shell substance was perforated by canals, and the exterior of the ventral valve was often profusely ornamented with tubular spines, sometimes restricted to the hinge region. The brachial organs, contained in a depression of the dorsal valve, were not supported by any internal skeleton. In some genera the two valves were united solely by muscles; in others hinge-teeth and sockets were developed. The distinct impressions of the adductor muscles are very characteristic of this family.

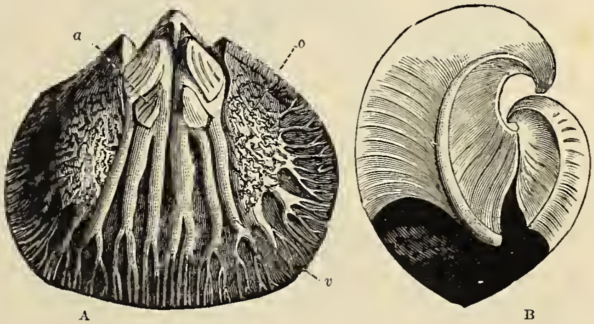


Fig. 10.—A, INTERNAL CAST OF DORSAL VALVE OF ORTHIS. B, SECTION OF PENTAMERUS, SHOWING CHAMBERS. (*After Davidson.*)

a, Adductor Muscles; *v*, Veins; *o*, Ovarian Spaces.

Members of the large family of the Strophomenidæ appeared in the Cambrian seas, and became extinct in the Upper Liassic period. The valves of these compressed shells were usually concavo-convex, and furrowed from hinge to margin. Hinge-teeth were present, and the breathing organs were supported by a short process. The figure of the genus Orthis (10, A), showing the impressions of the mantle, vascular and muscular systems, illustrates the manner in which the anatomy even of fossil species can be determined. In the Pentameridæ† (Fig. 10, B), or five-chambered shells, the articulated valves were divided into five parts or chambers. Those at the side were occupied by the arms and ovaries, and the V-shaped division near the beak by the digestive organs. The shell is smooth and imperforate, with a prominent beak. This family was represented only in the Silurian, Devonian, and Carboniferous epochs.

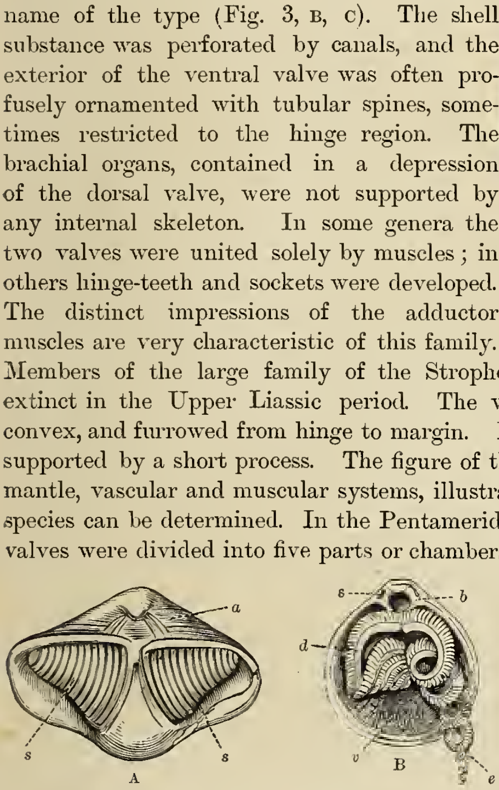


Fig. 11.—A, DORSAL VALVE OF SPIRIFERA GLABRA, CARBONIFEROUS. B, DORSAL VALVE OF RHYNCHONELLA PSITTACEA. (*After Davidson and Owen.*)

a, Hinge Area; *s*, Spiral Labial Appendages; *d*, Arms in Natural Position; *e*, Unrolled; *b*, Dental Plates; *s*, Sockets; *v*, Vascular System of Mantle.

THE SPIRE-BEARERS.

The name of this family, which comprises some of the most beautiful of the numerous fossil forms of the class, is derived from the spiral shape assumed by the calcareous labial appendages which nearly fill the interior of the dorsal valve (Fig. 11, A). The shells are ovate, elongated, and sometimes extended into wing-like expansions. The Spiriferidæ appeared in the Silurian seas, and became extinct in the middle of the Liassic period. Among the family of "Little Beaks," or Rhynchonellidæ, the valves are strongly articulated, and the generally imperforate shell is three-cornered, with a small-pointed beak (Fig. 11, B). The fleshy, spirally-rolled breathing organs are merely supported by a short calcareous process, and are therefore capable of extension beyond the margins of the shell. Professor Morse witnessed this operation, and states that the appendages can be unrolled and

* Latin, *producta*, produced. † Greek, *pente*, five; *meros*, part.

protruded nearly twice the length of the shell. They often remained extended a short distance for hours. Their movements were very sluggish, but the cirri were constantly in motion, and the shells sometimes closed upon the arms before they were retracted. This family was represented in Silurian times, by the type and other forms, in some of which the spires were coiled round and round like a watch spring. The Rhynchonellidæ culminated in the Jurassic seas; four or five species only survive.

THE TEREBRATULIDÆ.*

This, a most extensive family, comprises a great number of generic and sub-generic forms, which are usually characterised by the large-sized perforation in the ventral or pedicle valve, for the passage of the peduncular organ of attachment. The calcified support for the respiratory and alimentary organs exhibits considerable modifications, which serve to distinguish one genus from another. Sometimes the loop is short and simple (Fig. 12, A); in the form of a ring (B); or it is long and doubled back on itself, as in Fig. 5, B, *l;* attached twice (Fig. 12, C) or three times (E) to the ridge or septum running down the centre of the valve. Again, the respiratory and food-securing organs may be supported by an anchor-shaped process (D), or by short ridges developed along the margins of the valves (G). It seems probable that the ringed type of loop is a further modification of the simplest and highest type—that of Terebratula. For the embryological researches of Friele have revealed the fact that in other genera the loop passes from a complicated to a simple type, assuming at successive stages shapes which are absolutely identical with the characters of those of full-grown individuals of other genera. This discovery, however interesting and suggestive as throwing light on the genetic descent and relationship of the Brachiopoda, does not really affect the value of the calcified loop for classificatory purposes, as each genus is distinctly characterised by its special form of loop in adult animals. The Terebratulidæ include the majority of existing species of the class. It was represented in the Silurian seas, and steadily increased in numbers until the dawn of the Tertiary epoch, since when its specific representatives have been somewhat reduced.

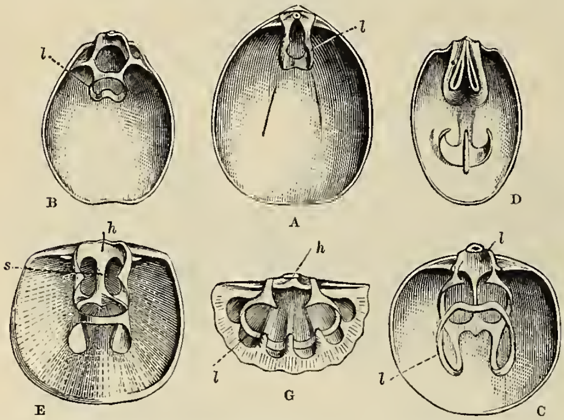


Fig. 12.—A, LOOP OF TEREBRATULA; B, TEREBRATULINA; C, TEREBRATELLA; D, BOUCHARDIA; E, MEGERLIA; G, ARGIOPE. (*After Davidson.*)
h, Hinge; *l*, Loop; *s*, Septum.

THE THECIDIDÆ.

The genus Thecidium is the only member of a family which apparently came on the scene of life in the Triassic age. Living species attached by their ventral valve to corals, moss-animals, and dead shells of their race, abound in the Mediterranean sea, where they were dredged in great numbers by M. Lacaze-Duthiers, who kept them alive for several weeks, and gives the following account of their habits. The animals are certainly sensible to light, for the valves were abruptly closed on the interposition of any shadow. They were generally opened very slightly; the upper moved at right angles on the hinge line, and shut with the rapidity of lightning when the animal was disturbed. The ciliated folded breathing organs, supported by a calcareous loop, are sunk in hollows in the attached valve. The shell is small, thick, strongly articulated, and its substance perforated by canals.

Fig. 13. — THECIDIUM MEDITERRANEUM, AS IN LIFE. (*After Lacaze-Duthiers.*)

The Brachiopoda apparently prefer rocky shores to muddy bottoms; they are much localised and generally occur in great abundance in their favourite haunts. Out of the one hundred and thirty known genera, only twenty-two are represented by living forms. Many of these survivors have a wide geographical range, and occur at most varied degrees of depth. Ten species are found off the British coasts. The Lingulidæ, as a family, exist in very shallow water living half-

* Latin, *terebratus*, perforated.

buried in sand shoals or mud banks, and are occasionally left dry by the receding tide. They are very abundant in certain localities, in from 7 to 60 fathoms in the tropics, the China and Japan seas, and off the Australian and Pacific coasts. They are also plentiful at low water in the Philippine Islands, and on the Atlantic shores of North America. No member of this family inhabits deep water. The "Helmet Shells" (Craniadæ) exist in from 300 to 800 fathoms off the shores of Japan and Australia. The "Disc Shells" (Discinidæ) are generally dredged in from 3 to 50 fathoms off Japan and the South Pacific coasts. They range from Baffin's Bay to south of the Cape de Verde Islands; from the Arctic regions to the equatorial Atlantic. One interesting little species of this family has succeeded in adapting itself to life in the abysses of the ocean, and enjoys a bathymetrical range of from 690 to 2,475 fathoms. It was dredged at this depth at several stations by H.M.S. *Challenger*, from its home at the bottom of the Atlantic, whence its specific name of Atlantica is derived. This species, however, also occurs off Australia, for, like all abyssal forms, it enjoys a wide geographical distribution. It is the only member of the more highly organised group (Tretenterata) which can really be considered an inhabitant of the deep seas.

The species of the order Clistenterata are more frequently found in deep waters, although some, like the Australian Waldheimia, are merely washed by the tide and may be gathered by the hand, "like limpets on the shore." A species of the genus Kraussina is also left dry by the tide on that desolate rock of St. Paul's Island in mid-Atlantic. The family of "little beaks" is represented in the New Zealand area, off Japan, in the Arctic and North and South Atlantic Oceans, at depths varying from 10 to 690 fathoms. Thecidium (Fig. 13) inhabits the Mediterranean Sea, and may also be sought off Jamaica and the Mauritius in from 30 to 300 fathoms. But it is among the universally-distributed Terebratulidæ that the greatest variety of depths has been recorded: from 200 to 600 fathoms being the usual limit of the majority of species. Five, however, are known to live at from 1,000 to 1,500 fathoms; four in from 1,500 to 2,000, and three in from 2,000 to 2,900 fathoms. The *Challenger* dredged a very pretty little species of Terebratula at the last-mentioned depth (Fig. 14). Its occurrence off Valparaiso in 2,160 fathoms, and South Australia in 2,600 fathoms, affords another illustration of the fact that the deep-sea Brachiopoda are uniformly and widely diffused. The same species always recur at stations far distant from each other, a fact that is probably owing to the uniformity of the temperature, which below a certain bathymetrical limit never exceeds a few degrees above freezing-point. It is also very remarkable that the shells of the deep-sea forms are invariably delicate, and so transparent that the muscular impressions and the shape of the loop can often be distinguished from the exterior. Yet, notwithstanding the exceeding delicacy and fragility of their shells, the animals sustained life at a depth where the pressure of the water exceeded two tons and a half to every square inch of surface.


Fig. 14.—TEREBRATULA WYVILLII. 2,900 fathoms. (*After Davidson.*)

Thus it is evident that these shell-fish can adapt themselves to life under the most varying conditions of temperature and depth, whether in Arctic or Tropical regions, at low-water mark, or in the untroubled abysses of the ocean. Nor is their range in time less extended than their bathymetrical limits or present geographical distribution, for the Brachiopoda were among the first representatives of life in the primeval oceans.

Truly of most ancient lineage, they are found in the lower Cambrian strata, and formed a very important feature of the animal community in the following "ancient life" epoch, often called the "reign of molluscs" from the numerical preponderance of those organisms. Members of the Tretenterate group were, according to our present knowledge, the first to make their appearance in the Cambrian seas, where the remains of the earliest known species, a Linguloid form (*Lingulella primeva*), were embedded. Only two genera, Lingula and Discina (Figs. 7 and 2,), out of about 130, have persisted throughout all the geological ages up to the present day. Crania, Rhynchonella, Terebratula, Waldheimia,* and Glottidia, a sub-genus of Lingula, date from the Silurian. But the majority of the remaining 124 generic forms enjoyed a comparatively brief existence, appearing in one era to vanish at or before its close. Thus, three

* The genus, previously only known from the Jurassic upwards, has been discovered by Mr. Davidson in strata of Upper Silurian age.

only are special to the Cambrian, twenty-nine to the Silurian, fourteen to the Devonian, nine to the Carboniferous, while four are especially characteristic of the Permian strata which terminate the Palæozoic, or ancient life epoch, during which about 3,000 species existed. Some of these occur only in certain localities, but many had as wide a geographical range in the past as some representatives of the class in existing oceans. A species of the "spire-bearing" family, for instance (*Spirifer lineatus*), is found in the Carboniferous rocks of North and South Europe, Asia, America, and Australia. When the Silurian rocks were deposited, the Brachiopoda far exceeded their bivalved contemporaries in number, but to-day the conditions are completely reversed, and the Lamellibranchys outnumber them in the ratio of forty-four to one. During the mesozoic ages, the Brachiopoda declined in numbers, and in the more recent Tertiary epoch their ranks became sadly thinned. In the existing oceans they can be numbered only by tens instead of by thousands, for but an insignificant remnant of 130 species now survives. They abound in all marine deposits, and are most valuable guides in determining the relative ages of all the stratified rocks.

The sexes are distinct in these bivalves, which are always reproduced by means of fertilised ova, and never by the process of budding or gemmation. The eggs are white, kidney-shaped, and irregular, and are discharged in the form of a white powder between the margins of the mantle, and hang in clusters from its terminal fringe of bristles. They are deposited from April to September, and the animals attain their full growth in a single season, and some, it is believed, live but a year. The embryo, soon after its development from a circular cellular mass, becomes subdivided into two, three, or four lobes or segments of unequal size (Fig. 15, A). They are contractile, and swim freely by means of the movable cilia with which they are covered. Eye-spots and long tactile bristles are developed. Subsequently the embryo attaches itself by the hinder segment, which forms the head of the animal, the internal organs make their appearance, are succeeded by the mantle, and the rudiments of the shell plates, which distinguish the adult animal. The embryos of existing representatives of the earliest known hingeless forms, Lingula and Discina, are so closely allied as to be almost indistinguishable. The shape of the shell, and the length of the peduncle in some members of the later-appearing family of Terebratulids, in some stages presents a remarkable resemblance to Lingula, while, at a more advanced stage of growth, the extreme prolongations of the beak, or rostral portion, recalls the corresponding structure in the complex and widely distributed Silurian Trimerellidæ. At another stage, the hinge area resembles that of the Spiriferæ, and the young Terebratulina assumes the position those genera must have adopted.

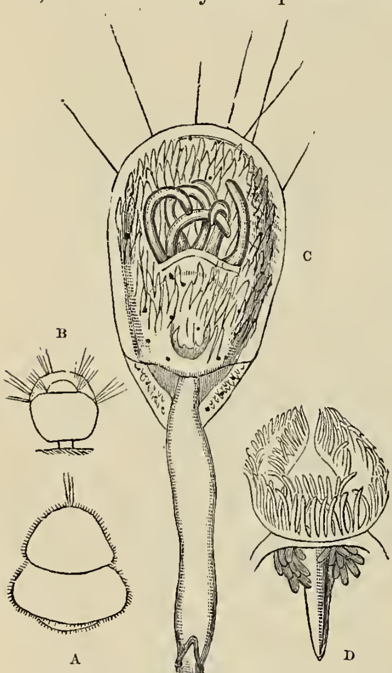


Fig. 15.—A, FREE-SWIMMING CILIATED LARVA OF TEREBRATULINA; B, ATTACHED; C, LATER STAGE; D, HORSESHOE STAGE OF LOOP. (*After E. S. Morse*).

Morse thus describes the actions of a young Terebratulina. "The cirri of the arms moved frequently and in various directions, though generally performing a grasping motion, as if securing some bit of food, imitating precisely the movements of the cirri in the Bryozoa; and this resemblance was the more complete from the fact that the tentacles were densely clothed with cilia, and their movements caused visible currents in the water." In a more advanced stage, the cirri (fringes) stand erect upon the arms, and vividly recall the horseshoe-shaped forms among the Bryozoa. In fact, the alliance between the mantle-breathing bivalves and the Moss-animals is a very close one, although at a first sight it must be admitted that no two animal types could apparently be more dissimilar.

The facts concerning the life history, distribution, and classification of the Brachiopoda, here briefly epitomised, have been mainly derived from Davidson's well-known contributions to the "Memoirs of the Palæontographical Society," the "Geological Magazine," and the "Results of the

Challenger Expedition" (Zoology, Vol. I.). For anatomical structure, the works of Hancock, Owen, Huxley, King, and others have been consulted; while for the habits of the animals, embryological history, and systematic position of the class, Morse's various memoirs (Boston Society of Natural History) have been largely quoted. To Mr. T. Davidson, F.R.S., and Professor E. S. Morse my acknowledgments are due for further information kindly afforded.

THE BRYOZOA, OR MOSS-ANIMALS.

This group includes a number of usually compound organisms, often of small size, and presenting remarkable varieties of form, epitomised in the English names of sea-mosses, sea-mats, sea-scurfs, and lace-corals, which are applied to the most familiar examples of the class. Some are erect, like, seaweeds, leafy, branching, and plant-like in their mode of growth; others resemble fungi, sponges (Fig. 19, A), or simulate the delicate net and lace-work of the Coral. The creeping, sub-erect, and encrusting species form a distinct type, and adhere to submerged rocks, shells, and stones, grow semi-parasitically on crabs, worms, or infest seaweeds, and even members of their own race (Fig. 19, B). "Some," writes Mr. Busk, "soft and flexible, composed wholly or in part of a horny substance, form delicate growths which yield gracefully to every motion of the waves, whilst others, firm, rigid, and unyielding as the rocks they live upon, bid defiance to the ravages of time and tempest."

Fig. 16.—BUGULAPUR PUROTINCTA. NATURAL SIZE. (*After Hincks.*)

All the Moss-animals live in water, and the greater number of species inhabit the ocean at depths ranging from between tide-marks to two hundred fathoms. Some parts of the sea-bed are covered with masses of their dead and living forms, and the blanched skeletons of the commoner species, many of which might be mistaken for seaweeds, are among the most frequent objects cast up by the retiring waves on to the shore. During life they are often very beautiful, the hard parts and associated structures being transparently white, reddish-brown, and occasionally of a purple, blue, or green colour. A few genera exhibit phosphorescent characters, and one (*Flustra foliacea*) has an odour of a somewhat indeterminable nature. Nearly all occur in the form of associated growths or colonies attached to foreign objects; members of one family (*Selenaridæ*), however, are free when adult, and move by means of the largely-developed projecting organs on the external surface of the colony, after the fashion of some Sea-urchins. A single genus (*Loxosoma*) lives a solitary, independent existence, attached by a foot-gland to living organisms, the buds to which it gives rise becoming detached from the parent stem. In all cases the colony is founded by a free-swimming embryo, which on fixation gives rise to a secondary bud, whence others rapidly develop, and thus the colony is formed by a continuous process of budding or gemmation. Some parasitic species slightly alter the surface of the shell they grow upon, eating away its outer surface, and reducing the shell whose shape they assume to extreme tenuity. Several members of the "lip-mouthed" sub-order (Cheilostomata) pierce their cellular habitations, probably by some chemical agency within the substance of the shell they infest. This perforating group, represented by living forms in the Mediterranean Sea and Atlantic Ocean, is known to have existed in Tertiary and Secondary epochs, and by some it is inferred, during the "ancient life" period also.

But the Moss-animals are not entirely confined to the ocean. A number of no less interesting forms have become adapted for life in the fresh waters of the land. Among these, a genus distinguished alike for the beauty and numerical abundance of its tentacular breathing organs, whence, indeed, its generic name of Cristatella * (Fig. 17) is derived, is specially remarkable as the most truly active member of its class. It is, in fact, the representative among the Bryozoa of the wandering genus Lingula of the Brachiopoda, and dwelling in lakes and ponds, creeps slowly

* Latin, *crista*, a crest.

on the flattened under surface of the colony, which forms an oval and contractile disc over the upper side of submerged stones.

The colonies, or Polyzoaria, vary in size from scarcely perceptible objects to branched or riband-like masses, in some cases several feet in length or in breadth. A moderate-sized one has been estimated to contain within an area of three square inches a population of forty thousand little animals (Gosse), and some of the larger growths comprise within their limits accommodation for two million individual occupants. But these were not necessarily all living at one time. The colony increases at the margins as fresh animals spring by budding all around, and although some of the inner and the older cells may for a while be unoccupied by active living tenants, the colony still grows; while, when one generation dies out, a second almost mysteriously supplies its place, and the once empty cells are peopled with fresh occupants. For the method both of individual and colonial reproduction is as varied among this diverse group of animals as the nature and mode of growth of the colonial external skeleton or the habits and structure of the individual, which all in turn present so many divergent features as render it difficult to give a generalised account of their structure and ways of life.

Fig. 17. — CRISTATELLA MUCEDO. NATURAL SIZE. (*After Allman.*)

Like the Corals, with which they were for so long confounded under the common name of "Polypi," the Moss-animals, and with far more apparent reason, were formerly regarded as vegetable organisms. Even Linnæus, although in the end admitting the wholly animal nature of the stony Corals, was never absolutely convinced that the horny and flexible forms—such as the wreath-like Corallines (Sertularia), and other widely-differing animal types with which the Bryozoa were then invariably associated, on the grounds of their common possession of an external horny or calcareous skeleton—were not really members of the vegetable world. Long after, when naturalists began to base their systems of classification more on the anatomical structure of animals than on outward form, it became evident that the group of Corals, as then constituted, included animals of very different types of structure. In 1827, Dr. Grant described the animal-inhabitant of the Sea-mats, or Flustra (Saxon, *flustrian*, to weave), as differing much from that of the wreath-corallines; and in the following year M. Milne-Edwards arrived at the same conclusion. Meanwhile Dr. J. V. Thompson, of Cork, had long been studying the marine productions of the Irish coast, and in 1830 he published the results of his investigations on several species of plant-like animals allied to Flustra. This type of animal he designated a Polyzoan, a name which at once distinguished it from the Corals. Soon after, the eminent German microscopist, Ehrenberg, separated the Corals into two groups, and defined several families of his class Bryozoa, in which he included, among others, the animal type previously called Polyzoa by Thompson. The question as to which name should be retained for the class, long a matter of debate, is still a subject of controversy. That of Thompson, undoubtedly the earlier, is adopted by many British and American writers on the recent species; while that of Ehrenberg, certainly most distinctive of the class as a whole, has always been employed by all continental authors, and is universally applied to the numerous fossil representatives of the class.

The Moss-animals were next entirely withdrawn from the confines of the stony corals and radiated animals; their molluscan characters were fully recognised, and they were ranked by M. Milne-Edwards with the Lamp-shells and Sea-squirts, as an inferior order of shell-fish, under the name of the Molluscoida, or mollusc-like animals. With the Lamp-shells they still continue to be placed, although at first sight these colonies of minute animals, protected by a common external structure, present no obvious resemblance to or affinity with the individual Brachiopod enclosed between and protected by its two-valved shell. Yet, in spite of this apparent dissimilarity, the animal inhabitant of each bryozoonal cell possesses many anatomical points in common with that of the Lamp-shells, so as to fully justify their joint association.

The Bryozoa have been subdivided by Nitzsche into two principal sections, the Ectoprocta* and the Endoprocta, characterised by differences in the position of the anal orifice of the alimentary tube. In the more numerous Ectoprocta, the vent (anus) is situated *outside* the circle of the tentacles surrounding the mouth (Fig. 18, B, C, *a*). In the Endoprocta, it occurs close to the mouth or oral

* Greek, *ektos*, outside; *endon*, within; *procta*, vent.

opening, and is therefore *within* the disc or stage from which those breathing organs originate. Both groups having the breathing organs or tentacles in a continuous series, are comprised in the Holobranchiata.* A third and somewhat abnormal form, Rhabdopleura (Fig. 18, A), has a divided or winged base for the tentacles—which from their mobility and position present a close resemblance to the brachial organs of the Brachiopods—at present constitutes the section Pterobranchiata.

The Moss-animals, whether in the form of a minute shrub sprung from a creeping root-thread (Fig. 16), or occurring in branched and riband-like encrusting masses, almost invariably consist of a colony of individuals protected by a common external skeleton or cœnœcium,† which forms a defensive covering like the shell of a mollusc, differing, however, from that structure, inasmuch as once formed it seems to have no further connection with the animal that originally secreted it, surviving its death, and increasing independently. The assemblage of cells forming the colony or polyzoarium is composed of no less than six distinct elements, all in reality of a truly cellular nature, and present in the higher forms of the class. (F. A. Smitt.) First comes the true animal cell, the zoœcium, which lodges a perfect Moss-animal. Two other kinds, devoid of inhabitants, have become metamorphosed into purely defensive organs; while some, the ovicells, are restricted to reproductive purposes. The stem-cells are simply elongated animal chambers; and lastly, the radical-cells, or root-fibres, which, sometimes hooked, act like little grapnels, mooring the colony to the soft organisms to which it is attached, or, directed upwards, terminate in free, tendril-like claspers, enabling the clinging animal parasite to gain a firmer foothold in the branches of the organism it infests.

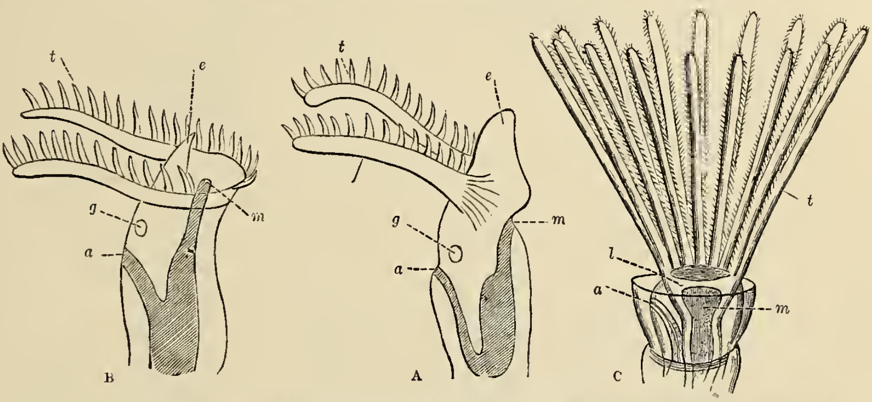


Fig. 18.—A, WINGED; B, CRESCENTIC; C, CIRCULAR TYPE OF GILL TENTACLES, ENLARGED.
(*After Hancock and Ray Lankester.*)

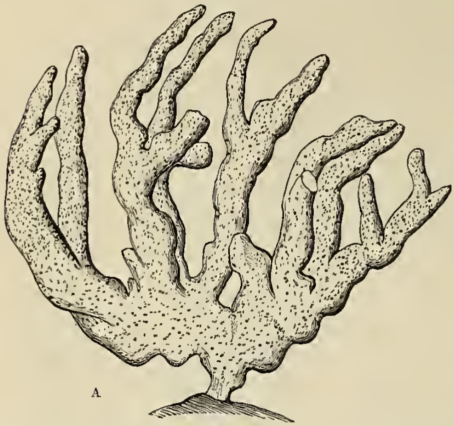
l, Lophophore; *t*, Tentacles; *m*, Mouth; *a*, Anus; *g*, Nerve ganglion; *e*, Epistome or foot: *f*, Divided or Winged base of Rhabdopleura.

The animal cell is composed of two distinct integuments. The outer, or ectocyst,‡—a product of the inner or endocyst—forms the external cell wall, and is either entirely of a fleshy, gelatinous, membranous, or membrano-gelatinous nature. In many cases it is partially encrusted with an earthy, horny, or calcareous substance. The inner cellular membranous layer or endocyst lines the outer wall. It always remains soft, transparent, is contractile, and corresponds with the mantle of the mollusc, and forms the body-wall of the animal. In the fresh-water genera its inner surface is clothed with vibratile cilia. The endocyst terminates in a fold near the horny ring or lophophore (Fig. 18, *l*), from which the tentacles (*t*) surrounding the mouth originate. Usually credited with the functions of the enlargement of the colony, it is now also associated with the production of a third element—a tissue, the true nature of which has only recently been determined, as one highly important to the general welfare of the community. The colony is in all cases derived from the metamorphosis on fixation of a single free-swimming larva, which develops into the primary Moss-animal, whence the colonial aggregation subsequently arises by a varied process of indefinite repetition.

Each of the animal cells forms the home of a minute, but separate, animal, often termed the polypide, which, in the majority of species, possesses all the organs requisite for the exercise of its individual, nutritive, and reproductive functions. It lives an independent existence in the cell or chamber it inhabits, to the inner wall of which it is usually attached by muscles, which enable its alimentary organs to partially protrude from, and retire within, its cell at its own pleasure. This

* Greek, *holos*, entire; *branchia*, gill. † Greek, *koinos*, common; *oikos*, house.
‡ Greek, *kustis*, a sac or bladder.

protrusion takes place at the upper part of the cell, which generally remains soft and flexible, and can often be drawn in, forming a sheath for the tentacles when the alimentary portion of the animal is retracted within the lower and harder portions of the true cell, and can be again everted on their re-appearance. The so-called orifice of the cell (Fig. 20, *or*) is in some instances protected by a row of spines—a tract le horny sheath crowned with bristles—and is in others effectually closed by a movable lip or shutter controlled by muscles specially developed for the purpose (Fig. 24, A). The shape of the animal cell is exceedingly variable. Sometimes the exterior is quite plain, or it may be rugged, spinose, or elegantly sculptured, as in the sea-scurfs. In others it is punctured with minute pores, which permit of the entrance of the sea-water. The larger of these are occasionally protected by delicate teeth-like processes, or a fine calcareous network, which acts as a sieve, and guards against the introduction into the interior of the cell of foreign substances, which might prove injurious or inconvenient to the occupant thereof. (Hincks.) Portions of the intervening outer cell-walls are occasionally of thinner structure, and contain minute perforations, through which the soft contents of the various cells are conveyed. These "communication plates" permit of that slow interchange of vital fluid which, with the exception of the association in a common lodgment, is the sole connection now believed to exist between the different members of the same colony.



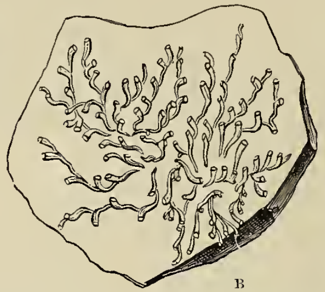


Fig. 19.—A, ALCYONIDIUM GELATINOSUM. (*After Van Beneden.*) NATURAL SIZE; COAST OF BELGIUM. B, PLUMATELLA ALLMANI. BROMLEY LOUGH, NORTHUMBERLAND. (*Enlarged, after Hancock.*)

Within this double-walled sac, or animal cell, the alimentary organs of the moss-animal are suspended in the perivisceral cavity (Fig. 20, *d*), and float freely in a colourless fluid, consisting partly of water admitted from the exterior, and products of digestion which have exuded from the alimentary canal, forming the equivalent of the nutritive fluid of the mollusc. The simple unarmed mouth (*m*), lying at the base of the tentacular hollow, communicates with a gullet (*œ*), spacious stomach (*s*), and a long intestinal canal (*i*), partially lined with cilia. This, bending somewhat abruptly at the base, turns upwards, and terminates in an efferent orifice (*a*) close to the mouth, occasionally *within*, but usually *without*, the circlet of gill-tentacles. The biliary glands are attached to the inner walls of the stomach. A single nerve ganglion (*g*), situated between the mouth (*m*) and the anus (*a*), with filaments radiating towards the tentacles and in other directions, represents the simple nervous system of the individual polypide. Both reproductive organs are generally present in the same individual. These consist of an ovary (*o*) attached either to the inner or body wall—or mantle lining of the cell—or above the spermary or testis (*x*) situated at the base of the perivisceral cavity (*d*), and connected by an elastic cord-like membrane (the funiculus, *z*) with the basal walls of the stomach.

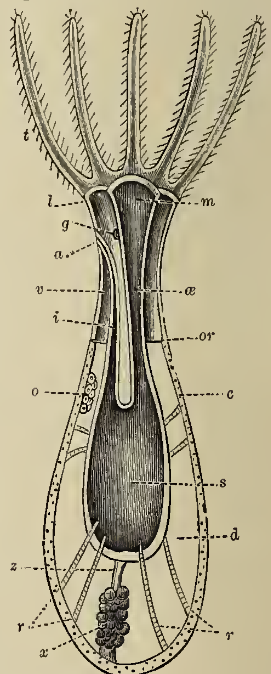


Fig. 20.—CELL AND ANATOMY OF A MOSS-ANIMAL.
(*Greatly enlarged. After Busk.*)
t, Tentacles; *l*, Lophophore; *m*, Mouth; *g*, Nervous Ganglion; *a*, Anus; *œ*, Œsophagus; *s*, Stomach; *i*, Intestine; *o*, Ovary; *x*, Testis; *z*, Funiculus; *or*, Orifice of Calcareous Cell; *c*, Ectocyst; *v*, Tentacular Sheath; *d*, Perivisceral Cavity; *r*, Retractor Muscles.

The muscles of the Bryozoon, composed of the simplest form of striated fibre, are very numerous and well developed. Two pairs of retractors, arising from the bottom of the inner lining of the cell, are attached to the alimentary tube, and serve to retract the whole with its

crown of gill-tentacles within the cell-orifice (Fig. 20, *or*); others having a like base, are fixed to the disc or lophophore (*l*), and direct the rotary movements of the tentacular crown. Some dilate the flexible and reversible portion of the cell (*v*), maintain the tentacular sheath in its right position when everted, and withdraw it to again enfold the tentacles on their retirement. Not less important are those muscles which control the immediate expansion of the tentacles, and their separate or combined movements, or traversing the walls of the alimentary canal assist the processes of digestion. According to the observations of various writers, the Moss-animal, when desirous of bringing its crown of tentacles into communication with the water, in order to obtain the food and air necessary for its existence, commences to erect itself by slightly straightening the alimentary tube. The contraction of certain muscles called parietals, which permeate the mantle lining the cell, press the fluid contained in the perivisceral cavity, or space lying between the cell wall and the intestine, upon the digestive organs. This pressure forces the tentacles to move upwards with the sheath, which is therefore pushed beyond the cell orifice until, more or less completely everted, it is held in place by its special muscles, and acts as a support to the alimentary organs of the little animal. The tips of the closed tentacles are the first to appear, and on the relaxation of the controlling muscles are rapidly unfolded, rotate with such speed and vigour as to create a perfect, if minute, whirlpool in their immediate neighbourhood. Into the vortex thus created by the movements of the cilia the small animalcules are engulfed, imprisoned within the circle of the ciliated breathing organs, and finally carried to the mouth. Then, if found suitable, they are swallowed by the muscular contraction of the walls of the gullet (*œ*), and pass into the stomach. When the nutrient particles have been extracted the waste products are forced by the muscles of the digestive system into the lower portion of the ciliated intestine, and finally ejected at the anal orifice.

If sufficient food has been secured, or on the slightest alarm, the polypide is instantaneously drawn within the protecting cell by the action of the great retractor muscles (Fig. 21, *gr*), the tentacles (*t*) retire within the sheath (*sh*), which is again inverted, and its ridge closes the mouth of the cell in those genera in which it is otherwise unprotected. All the inhabitants of the colony may be expanded at once, and retreat one by one, or all at the same time, with the rapidity of lightning. Some are shy in their habits, and, once disturbed, are long before they again emerge and venture to display their glories; while others stand rough treatment, and do not long keep within the retirement of their tiny cellular habitations.

The hollow tentacles external to the closed sac, which is perforated only by the openings for the mouth and anus, are the most important structures in the Moss-animal economy. They serve as respiratory agents, thus corresponding with the gills of the Bivalve and the brachial appendages of the Brachiopod; but act also as organs of touch and prehension. They vary from eight to eighty in number, and originate from the disc or stage, the lophophore,* which roofs in the perivisceral cavity. As the lophophore is circular in most of the marine forms, the gill tentacles present a bell-shaped appearance (Fig. 18, c); but in many of the fresh-water genera it terminates in free ends forming the crescent or horseshoe-shaped crown, whence the name of Hippocrepian bryozoa, often applied to this section of the class, is derived. There is no trace of the existence of a heart or vascular system, and the functions of circulation of the nutritive fluid are performed by means of the cilia clothing the membranous body wall lining the cell; circulation is, however, chiefly promoted by the muscular contractions of the mantle, which keep up an incessant current and movement of the fluid filling the perivisceral cavity. In this fluid the presence of white corpuscles has been detected.

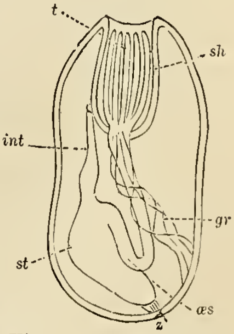


Fig. 21.—MOSS - ANIMAL RETRACTED IN ITS CELL. (*After Hincks.*)

sh, Tentacular Sheath; *gr*, Great Retractor Muscles; *int*, Intestines; *st*, Stomach; *œs*, Œsophagus; *z*, Funiculus.

One of the most important structures connected, not only with the life-history of each individual Moss-animal, but also with its relations to the rest of the colony, is that gelatinous tissue now known as the endosarc;† this consists of a cord-like prolongation of an elastic membrane (the funiculus, Fig. 20, *z*), which moors the base of the stomach to the bottom of the cell wall, and of divergent thread-like fibres, which, passing through the pores in the communication plates existing between the different cells,

* Greek, *lophos*, a crest; *phero*, I carry. † Greek, *endon*, within; *sarx*, flesh.

or through perforations in the stem partitions, link one Moss-animal to its neighbours, and thus unite the whole colony in a common life. The endosarc was at first considered to be the colonial nervous system, and to be associated with the singular phenomena of the regular and combined movements which occasionally agitate all the members of the same colony. But the researches of Joliet have proved that the tissue is not nervous in structure, and, according to this writer, the endosarc is a product of the mantle, originates the reproductive elements of the colony, and possibly enters largely into the composition of the tentacular sheath.

Such are the common attributes of a Moss-animal of the higher grade. In some forms, however, the pharynx (Fig. 23, *ph*) is more developed than in others, and the alimentary canal is divided into a higher or cardiac (*c*, *c*), and a lower or pyloric cavity (*p*). A gizzard is occasionally present in both marine and fresh-water forms, aiding the processes of digestion. Primitive excretory organs are also developed in the form of kidneys in some species. Many bryozoons are further characterised by the presence of a valvular organ, the epistome, situated on that side (neural) of the mouth nearest to the nerve centre. This singular organ (Fig. 18, *e*) has been compared with the epiglottis of the throat of mammalian animals. It is moved vigorously up and down when the alimentary organs are partially protruded from their cells. Regarded by some as an organ of sense, it acts as a protection to the entrance of the gullet (*ph*), and its existence distinguishes the "gullet guarded" moss-animals from those destitute of that structure; others, however, consider the epistome to be the equivalent of the foot of the mollusc, and there is no doubt that it serves as an organ of locomotion in that abnormal "mouth-footed" genus, Rhabdopleura, in which it retains its greatest development. (Fig. 18, A.)

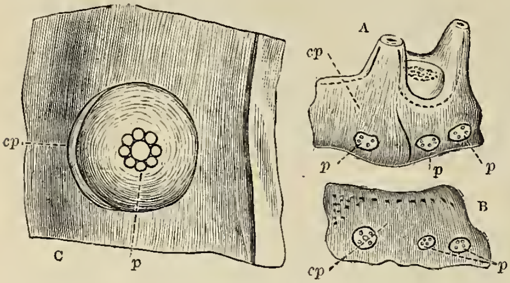


Fig. 22.—A, B, COMMUNICATION PLATES AND PORES IN CELL WALLS OF MEMBRANIPORA MEMBRANACEA; C, PERFORATED STEM OF ZOOBOTRYON. (*After Reichert and Nitzsche*).
cp, Plates; *p*, Pores.

Peculiar organs termed ovicells occur periodically in many bryozoa of the first rank, in the form of external capsules or enlargements of the cell wall. They are often situated at the upper part of the animal chamber over-reaching its orifice. (Fig. 24, B.) These modified cells bud from the membranous walls of the cell and communicate with the perivisceral cavity. As their name implies, the ovicells retain the fertilised ova, which migrate into the pouch thus formed, and are finally liberated when fully matured as active ciliated larvæ. In a more complex form of ovicell the external opening of this brood chamber is closed by a membranous capsule furnished with muscles, by which it is withdrawn to facilitate the passage of the embryo Moss-animal into the sea-water. Occasional enlargements of the cell wall, and cells restricted to reproductive purposes, occur in some members of the inferior marine sub-orders. But the true "brood-chamber" or marsupium appears only in the most highly organised sub-order of "lip mouthed" Moss-animals (*Cheilostomata*),* which are further characterised by the presence of two kinds of movable appendicular organs developed on the external covering of the colony, and irregularly distributed over its surface. The "vibraculæ" consist of a long slender bristle, thickest towards the base (Fig. 25, A, *v*), seated on a prominence in a hollow cup or receptacle—the representative of a cell—containing only the muscles which direct its lashing movements. Mr. Busk says:—"These whip-like appendages serve as defensive and cleansing organs, and may be observed in almost constant motion, sweeping slowly and carefully over the surface of the colony, and removing whatever might be noxious to the delicate inhabitants of the cell when the tentacles are protruded." In the family of Selenaridæ, which are never attached to foreign objects, even when adult, they are enormously developed, and serve as organs of locomotion, by means of which Mr. Busk has observed the colony to be transported from one locality to another.

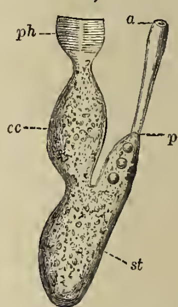


Fig. 23.— ALIMENTARY CANAL OF CELLEPORA. (*After Hincks*).
c, *c*, Cardiac, *p*, Pyloric cavity of Intestine.

The second kind is that one form of which was first recognised and described by Ellis, in a

* Greek, *cheilos*, lip.

species to which he gave the name of the "birds' head coralline." They are known as "avicularia," from the strong resemblance the most perfect present to a bird's beak, and are always composed of a chamber lodging muscles, and sometimes a tiny tuft of bristles seated on a prominence—possibly a tactile organ of sense—a more or less developed mandible, and a horny beak which can be brought into, and withdrawn from opposition, by means of two sets of muscles. The avicularia are of three distinct types, progressing from the rudimentary form of a dwarfed cell of the colony with an enlarged lid or operculum—"the immersed" (Fig. 24, B, *d*)—to those seated on the cell wall with a small chamber and mandible—the "sessile" (Fig. 25, B)—up to the ultimate type, "the pedunculate" (Fig. 25, C), which are situated on a movable jointed stalk, look like a bird's head, and sway to and fro snapping their jaws incessantly. These stalked forms have been credited with an alimentary function, for they seize small organisms, usually worms, and retain them pertinaciously in spite of their vigorous efforts to escape. But it is evident that they are not able to convey them to the mouth, which is, moreover, too small to swallow the objects generally captured. In accordance with the views of Mr. Hincks, the ciliated tentacles are sufficient to secure regular nourishment for the animal, and the avicularia are charged with a purely defensive function. "They may either arrest or scare away unwelcome visitors. Their vigorous movements, and the snapping of their formidable jaws, may have a wholesome and deterrent effect on loafing annelids, and other vagrants; whilst the occasional capture of one of them may help still further to protect the colony from dangerous intrusion."

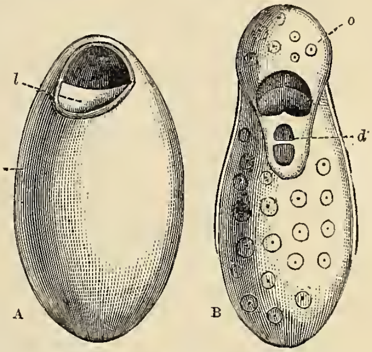


Fig. 24.—CELLS OF CHEILOSTOMATOUS BRYOZOON. (*Enlarged after Busk.*)
c, Animal Cell; *l*, Lid or Operculum; *o*, Ovicell; *d*, Immersed Avicularia

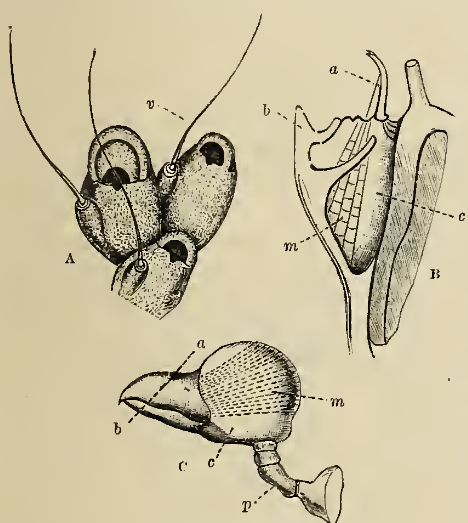


Fig. 25.—A, PORTION OF POLYZOARIUM WITH VIBRACULÆ, *v*. (*After Hincks.*) B, SESSILE, C, PEDUNCULATE AVICULARIA. (*Enlarged after Busk.*)
a, Mandible, *b*, Beak, *c*, Chamber, *m*, Muscles, *p*, Peduncle.

The avicularia, however diverse in size, shape, and position, may all be regarded as metamorphosed "animal cells." The operculum becomes first modified until through successive stages the true "bird's head" form is developed, and the cell contains merely the machinery by which the mandibles are worked. In this state they present, as Professor Huxley has shown, a remarkable resemblance to the valves of the brachiopod shell, in which the arrangement of the muscles, and the articulation of the two valves, correspond closely with the movable jointed mandible of the bird's beak in the operculated bryozoa. The "avicularia" are also linked by a series of transitional forms with the vibracular organs, which likewise consist of a chamber lodging muscles, and a movable bristle. Mr. Hincks describes the vibraculæ as acting sometimes independently of each other, and at others in combined action, as though swayed by a sudden impulse, yet with the perfect regularity and order of a machine. From this fact he derives an argument in favour of some kind of colonial sensation and means of communication. The occasional simultaneity of the movements of the vibraculæ was also noted by Mr. Charles Darwin,* who gives an interesting description of both kinds of the

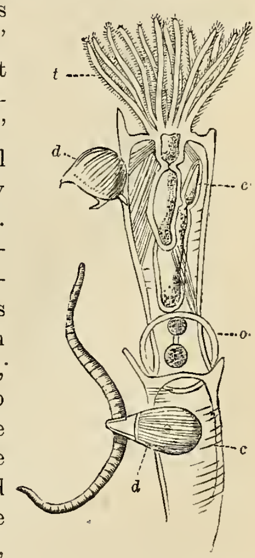


Fig. 26.—CELLS OF BUGULA AVICULARIA, WITH AVICULARIA (*d*) HOLDING A WORM. (*After Busk.*)
c, Cell, *o*, Ovicell, *t*, Tentacles, *d*, Avicularia.

* "Voyage of the *Beagle*," p. 201.

appendicular organs as observed by him in living specimens, off the coast of Tierra del Fuego in 1846.

The subjoined table gives the classification of the Sea-mosses, and the approximate inter-relationships of the minor groups, commencing with the higher forms. Sub-orders and genera known to be represented by fossil species are printed in italics :—

HOLOBRANCHIATA.

ECTOPROCTA
- *Cheilostomata*, marine, Flustra, Bugula, *Cellepora*, *Membranipora*.
- *Cyclostomata*, marine, Stomatopora, Hornera, *Fenestella*, *Lichenopora*.
- Ctenostomata, marine, Bowerbankia, Victorella, Mimosella.
- Paludicella, fresh-water, Paludicella, only.
- Lophophea, fresh-water, Lophopus, Alcyonella, Plumatella, etc.

ENDOPROCTA
- Pedicellina.
  - Pedicellina, marine.
  - Urnatella, fresh-water.
  - Loxosoma, marine.

PTEROBRANCHIATA.
Podostomata (mouth-footed).
Rhabdopleura, marine, only.*

ORDER HOLOBRANCHIATA.

THE ECTOPROCTA.—THE CHEILOSTOMATA.

Members of this highly-organised group are usually, as their name implies, distinguished by the presence of a horny lip or shutter, which, moved by special muscles, effectually closes the orifice of the cell on the withdrawal of its animal occupant. The external layer of the cell wall (ectocyst), sometimes fleshy or horny, is more often of a calcareous nature. The Cheilostomata are further characterised by the frequent presence of those singular outgrowths of the colonial skeleton—the vibracular and avicularian appendages already described. The former occur more frequently than the latter, with which, moreover, they are occasionally associated. The bases of these organs—often preserved in a fossil state—aid in the determination of genera. The marsupium, or "brood-chamber," also distinguishes these Moss-animals, which undoubtedly exemplify the most perfect form of bryozoonal organisation, although, at the same time, that which—farthest removed from the molluscan type—illustrates the effects of degeneration resulting from the adoption of a stationary life. In Moss-animals with a circular-mouthed cell (Cyclostomata, Fig. 27), the ectocyst is likewise more or less encrusted with a calcareous secretion, and the orifice of the usually long and tubular cell is generally unprotected by any apparatus for its closure and protection of the more simply-organised animal. But members of this group occasionally possess a modified operculum, which links them with the perfectly "lip-celled" Moss-animals, some of which in turn present external features of the Ctenostomata † (Fig. 28), a third sub-order, which includes a number of remarkable species, for some are fleshy, irregular, and spongious; others horny, plant-like, with flexible movable cells. The ectocyst, never calcareous, is either of a horny-membranous or membrano-gelatinous nature, and in many cases the cells arise at intervals from a creeping tubular stem, the stolon (Fig. 28, *s*). A portion of the tentacular sheath is fringed with a row of bristles connected by a thin membrane, which, drawn together on the retreat of the polypide, closes in and forms a hairy operculum or "comb-like" protection above the tentacles when those organs are retracted within the lower and harder portion of the cell. Some species inhabit brackish water, and exhibit modifications of the tentacular crown and other resemblances to the fresh-water forms.

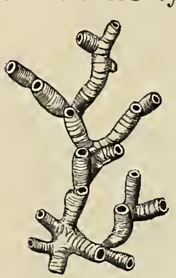


Fig. 27.—STOMATOPORA DICHOTOMA. (*After Zittel.*) GREAT OOLITE.

The sub-order Paludicella, is at present represented by a single, branched, fresh-water Moss-animal, which, of timid habit and a lover of obscurity, dwells in slowly-running waters, whence its generic name is derived. The animal of Paludicella inhabits a club-shaped, divided cell. The loop is circular, and, like all the foregoing members of the Gymnolæmatous section, the gullet is unprotected by the "epistome." All the remaining Ectoproctous forms are comprised within the sub-order Lophophea, founded on the genus Lophopus—the famous "Bell-flower" animal first

* A second supposed fresh-water Pterobranchiate has been described by Mr. Hincks, from Canada. † Gr., *kteis*, a comb.

described in 1741 by Trembley. In these "gullet-guarded" (Phylactolæmata) genera the epistome is developed, and, as the arms of the lophophore are either free or suppressed, the tentacles usually assume a "horseshoe" or crescent-shaped crown, (Fig. 18, B.) This sub-order includes a number of interesting forms, generally fungoid, gelatinous, limpid, or of a green, brown, or yellowish white colour. The majority are timid, light-shunning animals, and once disturbed are long before they venture again to expand their tentacles. The wandering Cristatella (Fig. 17) forms an exception to the rule, and seems capable of existing only in the full influence of sunlight in a whirlpool caused by the ceaseless agitation of its constantly-expanded crown. The fresh-water genera, to quote their chief historian, Dr. Allman, "may be sought in the still and running waters of the land, in the broad river and the rushing stream, in the pure cold mountain lake and the stagnant waters of the moory fen. In interest they yield not one jot to their brethren of the sea, and offer to the naturalist an inexhaustible source of gratification in the beauty of their forms and the wonders of their organisation."

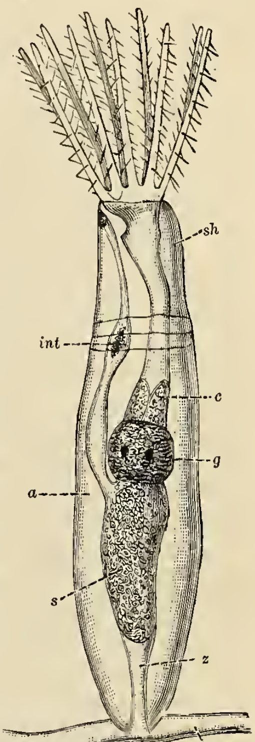


Fig. 28.—BOWERBANKIA. (*A. Farre. Enlarged after Hincks.*)
sh, Tentacular sheath; *a*, Cell-wall; *s*, Stolon; *c*, Cardia; *g*, Gizzard; *z*, Funiculus; *int*, Intestine.

THE ENDOPROCTA.

In this secondary group of inferior Moss-animals the anal orifice occurs *within* the tentacular crown instead of outside of it. In the single sub-order Pedicellina the tentacles are developed from the two sides of the upper margin of the cup-shaped cell. When at rest they lie partially concealed within the vestibule, as there exists no sheath into which they could be retracted. The animal does not leave the cell, and no muscles for its protrusion and retraction are developed. The ectocyst, or investing integument, is soft throughout, remaining entirely unhardened by a secretion of a calcareous or other nature. It closely surrounds the alimentary canal, and there is no true body cavity. The animal chamber is seated on a long contractile stem, from which it is generally separated by a diaphragm or partition. This peduncle (Fig. 29, *p*), sometimes furnished with spines, is very muscular towards the base, and capable of vigorous movement. The various members of the colony are united by the creeping tube or stolon (Fig. 28, *s*), from which the supporting peduncles spring at intervals. They often swing to and fro so actively that the colony resembles "a field of corn agitated by the wind;" and the muscular movements continue after the death of the animal inhabitant of the cup-shaped cell at the free end of the stem, which periodically falls away, and is reproduced by internal budding. Besides the marine Pedicellina, and a similar "urn-shaped" (*Urnatella*) fresh-water genus, this sub-order comprises a singular bi-sexual genus, the only known solitary Moss-animal. It lives fixed by a pedal gland—the representative of the molluscan shell-gland—attached to the caudal extremity of worms and other marine animals. The tentacles of Loxosoma are obliquely developed, and the body-cavity is attached to a contractile stem without any intervening partition. It is also devoid of the creeping tube or stolon.

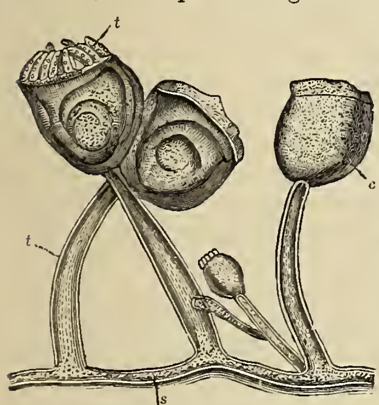


Fig. 29.—ENDOPROCTOUS TYPE (× $\frac{1}{100}$), PEDICELLINA CERNUA. (*After Hincks.*)
s, Stolon; *p*, Peduncle; *c*, Cell; *t*, Tentacles.

ORDER PTEROBRANCHIATA.

In the "mouth-footed" sub-order (Podostomata) the breathing organs arise from a winged or divided base (Fig. 18, A), and the mouth of the Moss-animal is situated under an enormously-developed organ, believed to be the equivalent of the "epistome" characterising the fresh-water genera. It serves as a foot, enabling the animal to walk up the walls of its long and tubular cell, to which it

is attached solely by the contractile "rod-like" funiculus. There is no mantle or inner layer of the cell-wall, and the cavity becomes filled with sea-water. No muscles are developed, the animal raising itself in the cell by means of the foot. Protrusion, a slow process, takes several hours to accomplish, and the animal is retracted by the elastic funiculus. The detached bud is furnished with two valve-like fleshy plates. The unique Rhabdopleura has been dredged in the British and northern seas in from ten to three hundred fathoms. Although a marine form, according to its describers, Sars and Allman, it presents many resemblances to the fresh-water genera, and is the representative of a very old type. It is supposed that the Graptolites are allied.

The Moss-animals sustain life under the most variable conditions of temperature and depth. Some affect shallow, muddy waters, others the regions of clear water or strong currents, and several species exist in the dim and unruffled abysses of the ocean. They are numerously represented in temperate regions, in the frozen waters of the east Greenland coast (Kirchenpauer), and in the warm latitudes of the Australian shores. They encrust the floating Gulf-weed with their silvery network, and grow on reefs between and on the different clumps of coral. Many species are universally distributed, others characterise boreal regions or the tropical zones. One, at least, leads a roving existence, and attached to the keels of ships is borne from clime to clime. The Cheilostomata and Cyclostomata are specifically most abundant from between tide marks to depths of 200 fathoms. They are somewhat less frequently recorded from 200 to 600 fathoms. A few species of the "lip-mouthed" forms frequent the brackish waters of friths and the mouths of tidal rivers, but the deep-sea species appear as usual to be widely diffused. Those dredged by H.M.S. *Challenger* have not yet been described, but the occurrence in the Atlantic of several of the "lip-mouthed" sub-order at depths varying from 1,500 to 3,000 fathoms has been noted. Among these abysmal forms was a species of a cosmopolitan genus, with a range from shallow water to great depths, and closely allied to members of a group that existed in Cretaceous oceans. This was brought up from between 2,000 and 3,000 fathoms, in a sterile region where other animal life was scarce. A peculiarly interesting and novel species (*Naresia cyathus*), arising from fibrous roots possessing the long, slender stem of the Endoprocta, supporting branches forming a cup, yet characterised by the colonial growth and appendages of the most highly organised class, was dredged in 1,500 fathoms off the Island of St. Vincent and on several other occasions. The Ctenostomata and other marine forms apparently prefer depths under a hundred fathoms. Two hundred and thirty species in all occur in the British seas. The fresh-water genera are distributed in the still and running waters of Europe, India, and North America, at depths ranging from a few inches below the surface to four feet.

Although the Bryozoa are of comparatively little importance as reef-builders in the present day, in past ages beds of limestone of considerable extent and thickness were built up by their exclusive agency. Fragments of the calcareous or horny skeletons of the "lip" and "circular-mouthed" species remain when the soft parts decay, and, frequently, preserved in a fossil state, testify that genera closely allied to living species have existed even from early epochs. Excluding a doubtful Cambrian form, we find a large number both of the erect and net-like forms (Retepora, Fenestella), and the delicate encrusting types, in rocks of Lower and Upper Silurian age. Some of these died out, others persisted, and many new forms appeared in the succeeding Devonian and Carboniferous epochs. Closely-related forms occur in the Trias. During the Mesozoic period, the Moss-animals contributed largely to the formation of extensive deposits, and attained their maximum. Jules Haime has described a number of Jurassic species, and D'Orbigny figured eight hundred from the Cretaceous rocks of France alone. Some Palæozoic and Mesozoic genera (Stomatapora and Diastopora) still continue to be represented; while the perforating Hippothoa has persisted from the Silurian, but the majority of generic forms are restricted to one life-epoch, and many occur only in a single geological horizon. Bryozoa abounded in the Miocene, and many species from the later Tertiary deposits are stated to be closely allied to, and even identical with, species living in the present oceans.

The soft and perishable nature of the common dermal covering in the Ctenostomata and Endoprocta would preclude their preservation in a fossil state. But it is highly probable that these sub-orders also existed in past ages. For the structure and embryological history of the few

existing species belonging to those groups seem to indicate that they represent the earlier forms of Bryozoonal life, when the primitive types were free when adult, as the ciliated larva is in the first stages of development. Thus the fixed state and colonial growth may be regarded as modifications occurring in the course of generations. The first kinds were probably solitary animals, the first step towards colonisation being the development of that creeping tube, the stolon, which unites the various shoots or cells into a colony of individuals, as in Pedicellina and the Ctenostomatous forms Thence all the varied colonial types may have differentiated, and all the organs for the protection and common welfare of the colony were eventually developed.

Differences in the form of the colony of parasitic species often result from the shape of the organisms they infest, and singular modifications adapted for the life that is led are of frequent occurrence. Thus, in a species of Membranipora which forms conspicuous white patches upon the Gulf-weed, and other Algæ, the skeleton is not universally hardened throughout. Certain parts remain flexible and so escape fracture, when the thousands of united cells sway backwards and forwards in the water, as the fronds of the weed are tossed to and fro by the waves. The shape of the erect colonies depends chiefly upon the mode in which the budding takes place, and the situation of the primary buds. In radiating and crust-like species, new cells often become interpolated. One of the common Sea-mats grows so rapidly during the summer, according to Nitzsche, "that the edges present a remarkable appearance. A marginal zone of perhaps one inch in breadth contains only half-developed cells; those nearest the centre, being least maturely calcified, are inhabited by smaller polypides; the younger ones are still uncalcified, and the cell orifice being as yet undeveloped, they cannot protrude. Only a very small part of a marine colony contains completely developed polypides. The younger cells at the extreme edge enclose immature buds, the older are empty, and only those cells intermediate between the elder and the younger contain fully developed animals."

Internal buds, called "Statoblasts," enclosing between two valve-like plates a polypide, which remains in a quiescent state for a variable period, are also developed on the "funiculus," and liberated as perfected Moss-animals, on the death of the parent. These are characteristic of the "gullet-guarded" fresh-water genera, some of which also multiply by fission—a form of budding in masses. The life-history of the marine colonies, is likewise perpetuated by internal buds in each cell. The chief features of this singular process, known as "the fall and renewal of the polypide," have been minutely described by F. A. Smitt, but are still the subject of controversy. It appears certain, however, that on the dissolution of the polypide, a portion of the digestive organs separates from the rest, and remains attached to the funiculus, a part of the endosarc, or common internal flesh of the colony. This "brown body," or remnant, increases in size, at the expense of the fatty globules by which it is surrounded, and is believed to give rise to a bud which develops into a perfect Moss-animal, resembles its predecessor in the cell, and may profit by the perfections of the colonial system. For, strange to say, the avicularian and vibracular appendages are not affected by the death of the animal inhabitant of the cell on the outer wall of which they may be developed, their existence being independent of it, and connected with the colonial system of which they are the outgrowths.

Thus is the increase of the colony secured, and the life-vigour of its inhabitants renewed and perpetuated. A word as to its original development. In most Moss-animals, both reproductive elements are present in each cell. But there are a few exceptions to the general rule, as among some of the Sea-scurfs, the Ctenostomata, and in the solitary Loxosoma, in which the sexes are stated to be distinct, the tufts of separated animals consisting either of male or female individuals. Sometimes the ova, fertilised either before or after their expulsion in the water, are set free in the perivisceral cavity, and escape only upon the rupture of the sac, and death of the parent polypide. Or they are dispersed by means of special organs, or pass through the brood chamber, and a period of further development. But in all cases they finally reach the water, as more or less developed, active, free-swimming larvæ. In this state they pass a variable period of time, swimming about by means of the cilia with which they are clothed. Eye-spots are developed, and long bristles for touch and guidance. These are absorbed when the little animal abandons its free life, becomes stationary, and develops into the primary polypide, and foundation cell of the colony. But before reaching this stage, the embryos pass through a number of phases of development, which, although varying according to the nature of the genus, may be all regarded as derived from a primitive ideal type. (Jules Barrois) The wandering,

segmented, ciliated, larvæ endued with temporary organs of sense, present a remarkable similarity to those of the Brachiopoda, and the presence of a bivalve shell in some species of Bryozoa, as well as the "horseshoe" stage of the loop amongst the Brachiopods, are further embryological points in common.

The anatomical features of adult individuals of each class are, moreover, very similar. Both the Brachiopod and the Moss-animal breathe and obtain nourishment by means of the pliant, tentaculated organs clothed with cilia which are protruded for that purpose, although the action in the former is constrained by the spiral shape of the fleshy, respiratory, and food securing organs, and the rigidity of the internal skeleton often supporting them within the mantle cavity. Neither possesses a heart, and the nutritive fluid is circulated entirely by ciliary, or ciliary and muscular action. In both groups a mantle is usually developed, and there is a close identity of type in the structure of the digestive organs, which, among the Brachiopoda, are attached to the inner wall separating the body or perivisceral cavity from the mantle chamber by muscular bands—the equivalents of the funiculus of the Bryozoa. "A certain parallelism may also be suggested between the leading groups of the Bryozoa and the Brachiopods. We have forms like Lepralia, attached by the region of their shells, this shell being calcareous, and exhibiting minute punctures which have been compared to similar markings in certain Brachiopods. So among the latter group do we find forms attached, as in Thecidium, and some species of Productus; and generally the articulated Brachiopods might be compared to such forms as Lepralia (a Sea-scurf); while on the other hand such genera as Pedicellina, with its long, pliant, and muscular stalk, or Loxosoma, with a stalk highly retractile, may be compared to Lingula." (Morse.)

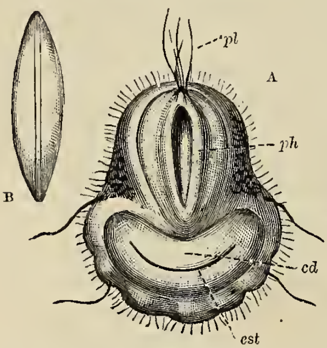


Fig. .30—A, FREE-SWIMMING CILIATED CHEILOSTOME LARVA. (*After Barrois.*) B, STATOBLAST OF FREDERICELLA. (*After Allman.*) *pl*, Ciliary plume; *ph*, Pharynx; *est*, Stomach; *cd*, Digestive Cavity.

It is evident, therefore, from embryological development and adult organisation, that the Brachiopoda and Bryozoa are so closely allied as to form a very natural group, and thus are they classed by the majority of authors. With regard, however, to the exact position in the animal kingdom to be occupied by the group thus restricted, opinions are far less unanimous; for it is also certain that in their earliest stages of growth the Brachiopoda and Bryozoa betray no molluscan characters. In fact they present such a close resemblance to similar stages of some worms, that such embryological authorities as Steenstrup, Morse, Kowalevsky, and Agassiz, deny their right to admission to the molluscan type. Professor Morse deduced the same conclusion from observations of the habits and structure of full-grown Lingulæ. But other zoologists consider these structural affinities merely as throwing light on the geological ancestry of both of these coeval types of organisms.

The literature of the Moss-animals is very copious. I am indebted, among others, to the following standard works:—"A History of the British Marine Polyzoa," 1880 (Thomas Hincks); "A Monograph of the Fresh-water Polyzoa of Britain" (J. G. Allman); "Catalogues of the Species of Marine Polyzoa in the British Museum" (G. Busk); and to the same author's contributions to the "Transactions of the Microscopical Society." For the history of the fossil forms of the class, I am indebted to the well-known works of Alcide D'Orbigny, Jules Haime, and the publications of the Palæontographical Society (G. Busk); for anatomical details, to the memoirs of Dr. Arthur Farre, P. J. Van Beneden, Karl Vogt, and T. Hincks, and the works of F. A. Smitt, Nitzche, Ray Lankester, Morse, and Vine; and for embryological details, to the complete "Embryologie des Bryozoaires' of Jules Barrois. To the Rev. T. Hincks, M.A., F.R.S., M. Jules Barrois, and also to Dr. A. Fritsch, Dr. Kirchenpauer, M. P. J. Van Beneden, and Dr. E. Von Martens, I wish to express my thanks for assistance and further information.

AGNES CRANE.

CLASS INSECTA.

CHAPTER I.

ANATOMY OF INSECTS.

Characteristics of the Arthropoda—Insects—Divisions of the Body—Segments of the Abdomen—Structure of the Thorax—The Jointed Limbs—Parts of the Leg—The Feet—The Wings—The Head—The Antennæ—The Organs of the Mouth—Segmentation of the Head—Modifications of the Mouth in Sucking Insects—The "Moulting"—The "Transformations" of Insects: Larva, Pupa, and Winged Stages—Internal Anatomy—The Nervous System—Structure of the Eye—Function of the Antennæ—The Digestive System—The Circulatory Apparatus—How Respiration is Performed—Reproduction—Classification.

The Arthropoda,* as already stated in the Introduction to Invertebrate animals in general, are characterised by having the integument of the body divided into a series of rings, generally hardened

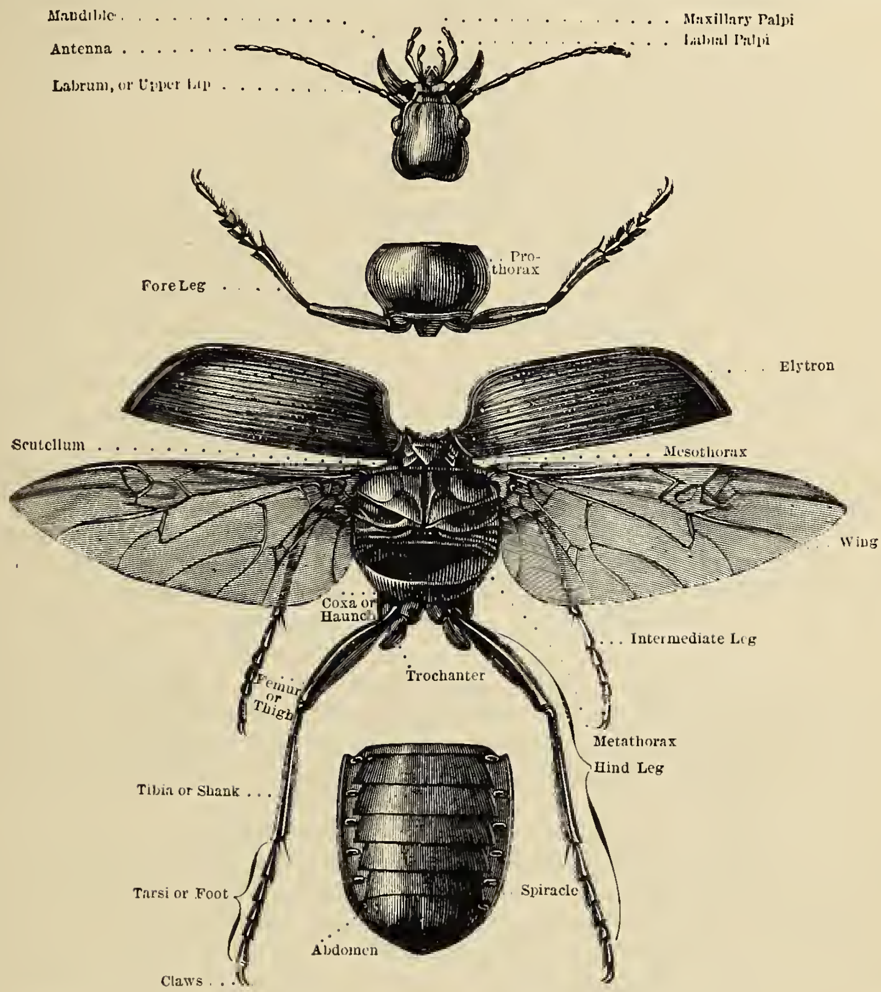


Fig. 1.—A BEETLE (*Calosoma sycophanta*) WITH THE HEAD, THE PORTIONS OF THE THORAX, AND THE ABDOMEN SEPARATED AND MAGNIFIED.

by deposition either of the horny substance, called *chitine*, of which the outer skin of these animals fundamentally consists, or of carbonate of lime, and united by soft flexible portions of the skin, which enable the parts to move more or less freely. These firm rings are called *segments*, or, by many anatomists, *somites*, and also *metameres*, as being more or less repetitions of similar parts. So far the Arthropoda agree with many Vermes, and in the older classifications the Arthropods and Vermes

* Greek, *arthron*, a joint; *pous*, a foot.

constituted two divisions of a single group (Annulosa), the leading idea in the foundation of which was the division of the body in this way into a series of segments, the greater part of which might be almost exact repetitions of each other. In the Arthropods, or jointed-limbed animals, however, we find, superadded to the simple Annulose type of structure, a greater or less number of jointed limbs serving the animal for progression either in walking or swimming.

Of the Arthropoda thus characterised the creatures known as Insects constitute the highest or most highly specialised type. They may be roughly defined as Arthropods in which the body is distinctly divided into three parts, called the head, the thorax, and the abdomen, furnished with three pairs of jointed limbs attached to the second division of the body, and breathing air by means of fine tubular organs which ramify in all parts of the body. Besides the legs the thorax generally bears one or two pairs of wings; the head has only a single pair of the organs known as *antennæ;* and the segments of the abdomen, or third division, have no limbs attached to them. These statements apply to the insect in its adult or perfect state; at earlier stages of its existence, as will be seen hereafter, it may present very different characters.

The segmented structure is most plainly shown in the abdomen (Fig. 1), and we will therefore commence by describing its general characters. There are usually no more than nine segments in this part of the body, and of these some are often suppressed or greatly reduced in size and concealed by others, so as to make the abdomen appear to consist of fewer than the theoretical full number of rings. In certain insects, on the other hand, there are, beyond the true ninth segment, certain parts which are regarded as representing two more segments, thus giving eleven as the total number of such parts that may exist in the abdomen of an insect (Fig. 2). The segments of the abdomen, as already stated, bear no jointed organs of the nature of limbs, but at the extremity of this part of the body we not unfrequently find certain appendages (jointed tails, ovipositors, claw-like pieces, &c.). The abdomen may be attached to the next division of the body (the thorax) by its whole breadth, or the segment or segments towards the base may be more or less narrowed, so that not uncommonly the actual union is effected by a very thin stalk. The segments themselves are composed of two half rings placed on the upper and lower surfaces (dorsal and ventral plates), and these may be firmly united to each other at the sides, or attached by a flexible membrane similar to that by which the successive segments are joined. In some cases where the wings form a protective covering for the abdomen (as in Beetles), the upper surface of the abdomen shows no horny plates, but is covered with a soft flexible skin.

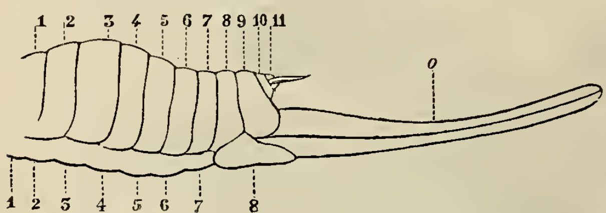


Fig. 2.—SIDE VIEW OF ABDOMEN OF DECTICUS, SHOWING THE SEGMENTS.
o, Ovipositor.

The *thorax* (Fig. 1) consists always of three segments, but, although in many insects this structure is as plainly recognisable as in the abdomen, it is very often masked, or even partly concealed, either by the close union of the segments, or by the shifting of the position of the parts of which the segments are composed, for the thoracic segments are more complex than those forming the abdomen. Thus in a perfect thoracic segment we can distinguish a dorsal plate (*notum*), and opposite to it a *sternum* (or "breast-bone"), and uniting these on each side two other pieces (*pleuræ*) placed one behind the other, of which the foremost is called the *episternum*, and the hinder one the *epimerum*. All these lower pieces generally take part in forming the socket for the attachment of the limb; they are united by sutures, but frequently so amalgamated together that the whole thoracic segment seems to form a complete ring. The three segments of the thorax are indicated in descriptions by distinctive names; the foremost is the *prothorax* (Fig. 1), the second the *mesothorax*, and the third the *metathorax*. In like manner the two principal pieces of which each successive segment is composed are distinguished as the *pronotum*, *mesonotum* and *metanotum*, and *prosternum*, *mesosternum*, and *metasternum*. In many cases the mesonotum exhibits in its middle a small raised plate, called the *scutellum* (Fig. 1), which is well seen in most Beetles; and in some insects a similar elevation is presented by the metanotum, the *post-scutellum*.

It has already been remarked that the thorax bears the three pairs of jointed limbs which are characteristic of Insects. One pair of these organs is appended to each segment of this division of the body, and thus the original division into three segments may be indicated even when the amalgamation of the segments themselves appears to be most complete. These limbs are inserted into sockets on each side of the sternum by means of their first joints, which may be spherical, or nearly so, and thus enable the limb to turn in any direction, or more or less elongated or ovate in form, when the movement of the limb from the socket will be more like that of a hinge. These first joints, called *coxæ* (Fig. 3, *a*), are followed by a piece usually of small size, the *trochanter* (*b*), which may be a ring-like joint uniting the coxa to the following joint of the leg, or a more or less triangular plate extending along part of the under surface of the latter. The third piece, generally the largest and most powerful joint of the leg, is the thigh or *femur* (*c*), at the apex of which the shank or *tibia* (*d*) is articulated by a hinge joint. Both these parts, but especially the tibia, are frequently armed with spines and bristles; the tibiæ in particular are very commonly furnished at their extremities with movably articulated *spurs*, which project considerably, and materially assist the insect in walking. The actual foot, or *tarsi* (*e*), is attached to the extremity of the tibiæ, and is composed of a variable number of joints, but never more than five. The joints of the tarsi often vary much in size and form, even in the same insect or in the same tarsus; they are generally clothed beneath with short stiff hairs, or modifications of hair-like structures, and the last joint bears at its apex a pair of movable claws, between or beneath which in the majority we find small membranous appendages, which are called *pseudonychia*, or *arolia*.

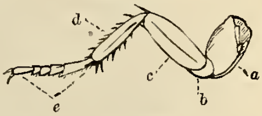


Fig. 3. — WALKING LEG OF COCKROACH.

These jointed limbs are modified in a great variety of ways, and their peculiarities of form and structure are of much importance in the classification of insects. Their chief use being for walking or running, they are, in the majority of these animals, subject only to minor modifications of the whole organ, or some of its parts; but where special functions have to be performed by them the changes are much greater. In this way the legs, or some of them, may be strongly compressed and widened, and provided with strong fringes of bristles to fit them for natatorial purposes, as in the Water-beetles; or shortened and thickened, furnished with great cylindrical coxæ, broad, toothed tibiæ and short concealed tarsi adapting them to the purpose of digging, as in the Mole-crickets; or elongated, and provided with very powerful thighs for jumping, like the hind legs of Grasshoppers and Locusts; or furnished with very long coxæ, thighs grooved and spined beneath, and tibiæ and tarsi arranged to fit into the groove of the thighs, rendering them formidable prehensile organs, of which the fore legs of the so-called Praying Insects (Mantidæ) are examples. Of the infinity of minor modifications, elongations, or abbreviations of parts, partial dilatations and contractions, development of bristles and spines, &c., there is no occasion to speak here; examples enough of them will have to be described in characterising the insects in which they occur.

Besides the legs the thorax usually bears one or two pairs of wings—in fact, in the majority of adult insects the whole of the organs of locomotion are confined to this region of the body. The front pair of wings when there are two pairs spring from the mesothorax, and the second pair from the metathorax, and always from the junction between the dorsal plate (*notum*) and the pleuræ. They are generally thin membranous organs, and notwithstanding their delicacy they consist always of two membranes continuous at their edges, and firmly attached to each by their inner surfaces. This peculiarity of construction is explained by the mode of formation of the wings. These are originally sac-like dilatations of the integument, which gradually become extended and more delicate in texture, until the inner surfaces come in contact and adhere one to another; but this does not finally occur until after the insect has arrived at maturity, and the two membranes, of which the wing is composed, can be at first easily separated. In most cases the wings are traversed by a greater or less number of veins, which branch in various ways, and generally form a sort of network. These veins consist primarily of air-tubes, similar in construction to those which ramify through all parts of the body, and serve, as will be described hereafter, for the purpose of respiration, and passing out of the thorax into the wings, spread out there between the two membranes. They are usually thickened by an increased deposition of horny chitine along their course, and as

this is usually of a blackish or brownish tint, the wing-veins become plainly marked. The mode of ramification of these veins is exceedingly characteristic of different groups of insects, and consequently of great importance in their classification. In some cases the deposition of horny material in the wing is not confined to the veins, but extends throughout the wing, which then becomes a horny or leathery organ, unfitted to assist in flight. This change usually takes places in the fore wings alone, which then serve as protective coverings to the greatly developed and more delicate posterior wings, the true organs of flight, which in repose are folded up and packed away on the back of the abdomen beneath the firmer anterior pair. In the Beetles (see Fig. 1), which furnish the best examples of this modification, the horny fore wings, called *elytra*, when closed, meet in a straight line down the middle of the back, usually concealing the whole dorsal surface of the body, except the first segment of the thorax (*pronotum*) and a small, shield-shaped piece of the mesonotum (the *scutellum*); in other insects which possess horny or leathery fore wings, these generally overlap towards the end; and in the Bugs only the first portion of the wing becomes horny, and the overlapping terminal parts are membranous. Such fore wings are called *tegmina* and *hemelytra*.

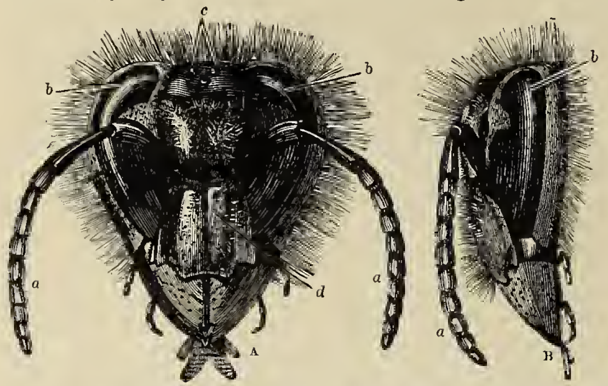


Fig. 4.—HEAD OF HORNET (*Vespa crabro*) ENLARGED, FRONT (A) AND SIDE VIEW (B).
a, Antennæ; *b*, eyes; *c*, Ocelli; *d*, Clypeus, which in the Front View conceals the Labrum.

Exceptionally many insects belonging to the most various groups, are always wingless, or the males are winged and the females apterous; and besides these certain entire groups, especially of parasitic insects, contain none but apterous species. Either of the pairs of wings may become greatly reduced in size, and apparently useless, while the other pair is fully formed; and in one whole order the fore wings alone are developed, and the hind wings are represented by a pair of small organs, consisting of a slender stalk, terminated by a little knob, which have received the name of *halteres* or *balancers*.

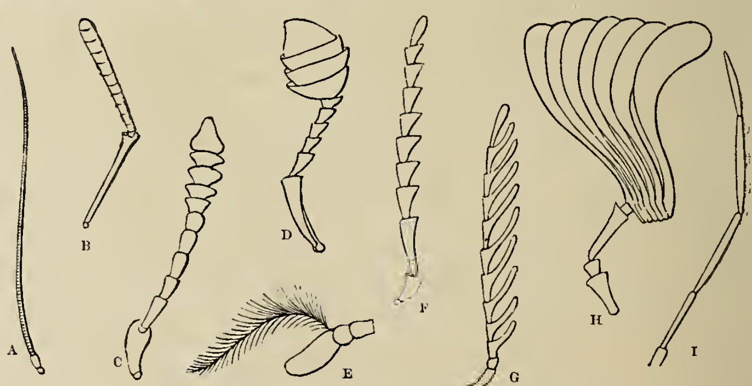


Fig. 5.—VARIOUS FORMS OF ANTENNÆ.
A, Locusta; B, Apis; C, Silpha; D, Necrophorus; E, Volucella; F, Elater; G, Ctenocerus; H, Melolontha, I, Agæus.

The *head*, or the foremost of the three divisions of the body (Fig. 1), when examined as a whole, appears to be a solid horny case, but a consideration of its appendages leads to the conclusion that it is composed of several segments. On the upper surface or at the sides it bears a pair of jointed organs called *antennæ* (Fig. 4, *a*), and a pair of *eyes* (*b*), which are almost always of the kind called compound; beneath it shows the organs of the mouth, which are subject to the most remarkable modifications.

The apparently homogeneous case of the head is considered to be divisible for descriptive purposes into various regions; thus the space between the eyes is called the forehead, in front of which is a part known as the *clypeus* (*d*), and the two together form the face. The crown of the head is called the *vertex*. Immediately in front of or beneath the clypeus, closing the mouth in front, is a small plate, usually movably articulated, and called the upper lip or *labrum*. On the vertex there are in many insects two or three simple eyes, or *ocelli* (*c*), the general structure of which and of the larger compound eyes will be explained farther on.

The *antennæ* (Fig. 5), which are attached to the head either in front of or between the eyes, are jointed organs of the most various development; sometimes excessively long, and many-jointed; sometimes very short, and composed of but few pieces; sometimes thread-like or necklace-like, and composed of joints of nearly equal thickness throughout, or tapering more or less towards the extremity; sometimes clubbed at the end by the enlargement of a certain number of the terminal joints, or gradually swelling from the base to near the extremity; sometimes serrated or feathered on one or both sides by the emission of more or less fine processes from the joints, or foliated by the widening of such processes into leaves, which may be more or less separated or pressed together, like the leaves of a book. In many cases, the first joint is longer and more robust than those which follow it; and sometimes the latter are attached to the first joints at an angle, instead of being continuous with it; such antennæ

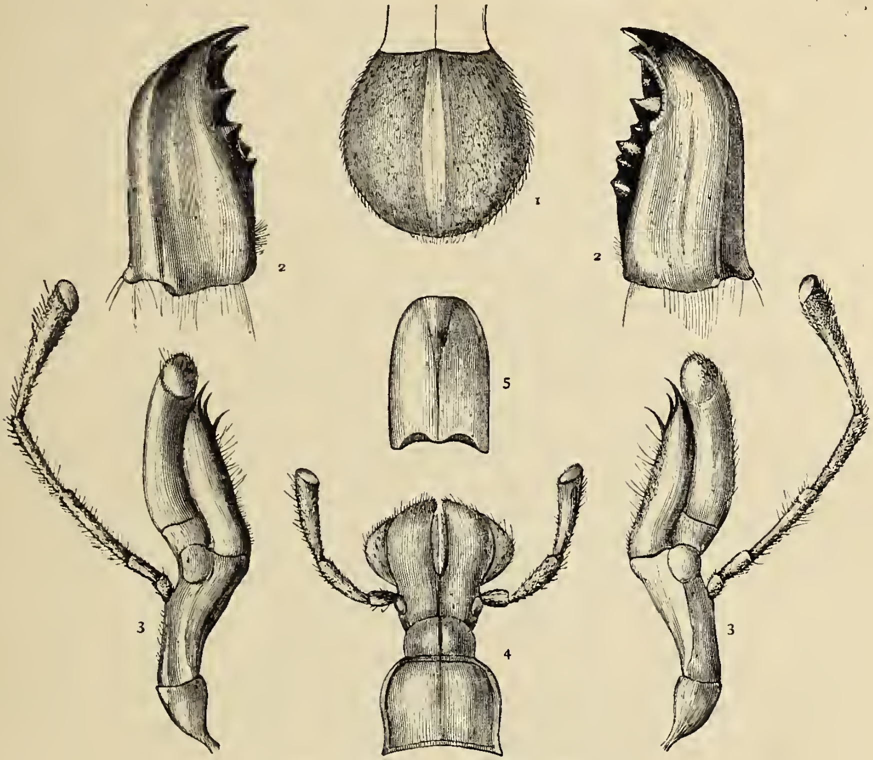


Fig 6.—ORGANS OF THE MOUTH.
1, Labrum, or Upper Lip; 2, Mandibles; 3, Maxillæ; 4, Labium, or Lower Lip; 5, Tongue.

are called kneed, or geniculate, and may be well seen in the common Ants. The differences of the antennæ furnish characters of great systematic importance.

The organs of the mouth (Fig. 6) must now receive our attention. The labrum, or upper lip, has already been mentioned. It is a small plate, usually of horny texture, articulated to the clypeus, but sometimes amalgamated with it, and really belonging to the head, although functionally forming part of the mouth. Immediately behind the labrum, in the mouth of a biting insect, we find a pair of solid horny organs, articulated to the head by a hinge-joint. They are often of considerable size, pointed at the apex, and armed with teeth, rendering them formidable weapons; at other times, shorter, and adapted rather to the gnawing of vegetable substances; but in all cases they are simple organs with no jointed appendages of any kind. This first pair of jaws is called the *mandibles.*

The jaws of the second pair, or the *maxillæ*, are by no means so simple, and in them we may trace some homology with the limbs attached to the thoracic segments. Thus the first joint of these jaws, the hinge-joint (*cardo*), which is placed transversely to the head, represents the hip-joint (*coxa*), and this is followed by a stem-joint (*stipes*), attached to it at a right angle, and corresponding to the thigh. On the outside of the latter is a separate piece, known as the scale (*squama*), which bears a

jointed organ, the *maxillary palpus;* and these two parts are regarded by zoologists as representing the shank and the tarsus. But besides these parts, the stem-joint bears on its inner side two masticating-plates, which are generally horny, variously-toothed, and assist in the division of the food This, of course, is a very general description of the structure of the maxillæ, which present many varieties of formation in different members of the class Insecta.

Below or behind the maxillæ we find what is apparently a single organ—the lower lip, or *labium*—but which is really composed of a pair of organs united together in the middle line. The labium closes the mouth from below, and consists of several parts, which have received special names. Thus its basal part, which represents the two hinge-joints of the maxillæ amalgamated together, is known as the chin, or *mentum;* the part in front of this, which may be either horny or membranous in texture, is called the *ligula*, and corresponds to the stem-joints, and other parts of the maxillæ. It is not unfrequently cleft in the middle, and may also have one of the other portions of each half separate, forming distinct divisions, called *paraglossæ.* The labium also bears a pair of palpi (*labial palpi*).

The preceding statements are intended solely to give a general idea of the arrangement of the parts composing the mouth in ordinary insects, to clear the way for the descriptions of those modifications of structure which, it will be seen hereafter, are of great importance in the classification of these animals. They are of importance, also, in connection with the theoretical structure of the head, which, although apparently composed of one solid piece, must be regarded as really consisting of several segments, intimately united to one another. If we consider what these segments may be, and what is their theoretical number, interpreting the insect head by its homologies with the lower arthropods, we find that the following constituents may fairly be distinguished. A segment bearing the eyes; a second segment, bearing the antennæ; and three more, of which the mandibles, maxillæ, and labium are appendages; the mandibles, which are solid, and bear no palpi, being regarded as representing only the basal joints (*coxæ*) of the members belonging to their segment. We thus get five segments in the head, which, taking eleven as the full number of segments in the abdomen, would give nineteen as the total number of segments in insects; but some anatomists are inclined to think that a second antenna-bearing segment must be imagined to exist, although in an undeveloped state, in order to bring the number of segments into accordance with that present in Crustacea. A remarkable and, so far as we know, perfectly exceptional, structure was described in 1879 by M. H. de Saussure, in a small Cockroach-like insect (*Hemimerus*), from the Gaboon, on the West coast of Africa. In this curious creature M. de Saussure finds *a second labium, evidently composed of two halves, and having a pair of palpi*, situated within the regular labium, and between it and the maxillæ. This, of course, would make the number of head-segments six, without reckoning the hypothetical second antennal segment, but unfortunately it is in the wrong place, and its occurrence is so exceptional that M. de Saussure is inclined to remove the creature possessing this remarkable character altogether from the class of Insects.

The modifications which these parts undergo, and which are characteristic of the orders, and other groups of insects, are very considerable, and will have to be fully described farther on; but a brief statement of the nature of the more important of them will not be out of place here, as placing the very curious phenomena in question before the reader in a connected form. The description given above indicates the general arrangement of the parts in the mouth of ordinary biting insects; and the differences presented by these are generally in matters of detail, such as the relative proportion of parts, &c. The first type which requires notice here is that presented by the Bees, in which the horny mandibles still retain their ordinary form and arrangement, and are, indeed, most efficient biting organs; whilst the rest of the organs of the mouth undergo important changes to fit them for the sucking-up of fluid nutriment. For this purpose the mentum, or basal part of the lower lip, acquires considerable power of movement, and the ligula, attached to it in front, becomes greatly elongated, at the same time that the maxillæ, which are also much elongated, acquire the form of thin blades, which embrace the sides of the ligula. By the union of these parts a sort of tube is formed, through which the food of the animal, consisting of the honey of flowers, can be easily sucked up, the mode of articulation of the parts enabling the whole composite organ to be pushed forward, or retracted beneath the head, at the will of the animal. Both labium and maxillæ are still provided with palpi.

In the Butterflies and Moths the change is apparently greater than in the Bees, although when the structure of the mouth in these insects is investigated the different parts are, if anything, more distinct. In Butterflies and Moths the upper lip and mandibles form three little plates, placed on the front of the head between the large eyes, but entirely concealed beneath the dense clothing of hairs with which that part is covered. Springing from the front of the head, beneath these rudimentary parts, we find a tapering organ, which is rolled up into a close spiral when in repose, but can be stretched out generally to a great length, and possesses considerable mobility. It is by means of this organ that the insects are enabled to suck up their food, which consists for the most part of the sweet juices of flowers; and, on investigation, it is found to consist of the maxillæ, which are produced into two thread-like organs, each bearing on its inner surface a half-tube, the junction of the latter forming the tubular organ through which the nectar passes. At their base these elongated maxillæ bear small palpi. The lower lip (or labium), like the labrum, is considerably reduced in size, and, indeed, may be nearly rudimentary; but, notwithstanding this reduction, it bears a pair of very large, usually three-jointed, palpi, which are in most cases densely clothed with hairs, and constitute those organs which may be easily observed in many Butterflies, projecting like a pair of stout horns in front of the head, and between which the spiral proboscis is rolled up when at rest.

In the other two principal types of haustellate, or sucking insects, all the parts of the mouth take part in the formation of the sucking organ, and in both the labium is converted into a sheath, within which are contained the representatives of the mandibles and maxillæ, reduced to a bristle-like condition. One great order of insects, distinguished at the first glance by the presence of only a single pair of perfect wings, the hind wings being represented by the little knobbed organs already described as halteres, is further characterised by having the labium converted into a sucker, often of a more or less fleshy texture, the upper cleft of which is closed by the elongated labrum, and within the tube thus formed are some bristle or lancet-like organs, representing the mandibles and maxillæ, frequently accompanied by an unpaired piece of the same kind, which appears to spring from the labrum, and is called the *epipharynx.* The number of bristles or lancets contained in this sucking mouth may vary not only in different families or species, but even in the two sexes of the same species. The full number of five is scarcely found except in the females of blood-sucking species (such as Gnats and Breeze-flies); in the males of these and in most other forms there are only three bristles, two of which are proved to represent the maxillæ by the attachment to them of palpi near their base. It is then a matter of uncertainty whether the third bristle is to be regarded as the epipharynx, the mandibles being altogether wanting, or as composed of the two mandibular bristles, united into one. The extremity of the proboscis in this type is frequently enlarged into a double pad, like a pair of lips, one on each side of the aperture. This has been regarded by many anatomists as representing the labial palpi, by others as formed by the ligula and labial palpi united. It is well seen in the common House-fly and in the Bluebottle. The function of the bristle-like organs in the interior of the proboscis is to pierce the tissues containing the blood or vegetable juices upon which these insects feed.

The Bugs and their allies have another form of sucking mouths, to which the name of rostrum is given. As already stated, its sheath also consists of the metamorphosed labium; but here it forms a longer or shorter beak, tapering to a point and divided into three or four distinct joints, which may very well represent the joints of the labial palpi united along the middle line. The jointed organ thus produced, which is articulated to the lower surface, or the apex, of the head, has its sides bent round in such a manner that their edges come into close contact, or may be united together, forming a closed tube, except towards the base, where the edges of the first and sometimes of the second joint remain at some distance apart. The little gap thus produced is, however, closed by the more or less elongated labrum, which thus again completes the sucking-tube. Within this tube we find four long and fine bristles, representing the mandibles and maxillæ, and these, as in the Flies which were last described, can be pushed forth and retracted by the action of muscles attached to their bases. They serve, as, indeed, in one case is pretty well known, to pierce animal and vegetable tissues, and thus enable the juices contained in them to be readily sucked up. The maxillæ in these insects are quite destitute of palpi.

Hitherto we have been considering the characters presented by the mature or adult insect; but

in many cases the young present a very different structure. In all Arthropoda the skin, or rather the epidermis or outer layer of the skin, is a continuous formation, and as completely outside the growing part of the organism as the hair or nails of quadrupeds or the feathers of birds. Perhaps the best analogue is to be found in the epidermis of reptiles—in both cases the outer layer of the skin is continuous, and, when once formed, incapable of receiving any increase of size ; hence, as the animal contained in it grows, there arises a necessity for the epidermis being thrown off from time to time. In insects this moulting (or *ecdysis*) regularly takes place ; in some the skin is changed as often as twenty times; and in a great number the shedding of the skin is associated with a great change of form.

This, however, is not the case in all. A considerable number of insects, chiefly parasitic in their habits, are hatched from the egg in a form almost exactly resembling that of their parents. Others, on making their first appearance in the world, more or less closely resemble their parents in shape, but nevertheless present certain differences, notably the absence of wings, which the latter possess (Fig. 7). In these instances the young insects in the course of growth change their skins several times, and at a certain period of their existence we find that behind the pronotum a pair of prominences not previously present have made their appearance. These are the cases containing the rudiments of the wings, which become fully developed after the last moulting. This condition of things may be observed in the Cockroaches and Crickets which frequent our kitchens, in the Grasshoppers, whose shrill cry enlivens the meadows in summer, and in the whole tribe of Bugs.

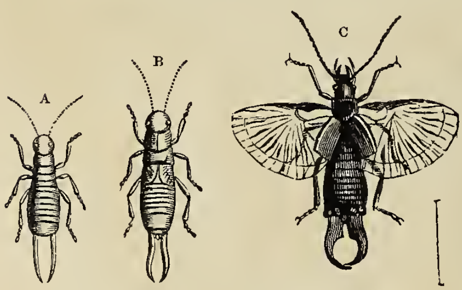


Fig. 7.—EARWIG IN ITS DEVELOPMENT.
A, Larva; B, Pupa; C, Imago.

In others, and indeed in the majority of insects, the change that takes place is much greater. The young insect creeps out of the egg in a form totally unlike that which it is ultimately to possess, and in some respects much more closely resembling that of the lower Annulosa, commonly known as Worms. Nearly all are soft, fleshy creatures, with the body divided into segments ; some are entirely destitute of limbs and of any distinct head ; others have no limbs, but are furnished with a horny head ; others have jointed legs attached to the first three segments of the body ; and others, again, in addition to these, possess a larger or smaller number of pairs of fleshy feet (prolegs) appended to some of those segments which represent the abdomen. In common parlance, the headless and footless forms are called *Maggots ;* those with a head and no feet, and some of those which possess legs, are known as *Grubs ;* and the forms with legs and prolegs are generally termed *Caterpillars.* The term *larvæ* is applied to all the different forms by naturalists, as also to the young insects above referred to, which resemble their parents in most respects except the entire absence of any trace of wings.

At the close of this so-called larval period of existence, however, there is a very great difference in the course of events in the two series of insects. As already stated, at the last change of skin, or, in some cases, at a somewhat earlier one, the larvæ which resemble their parents in general form acquire rudimentary wings, enclosed in cases which lie upon the sides of the body, behind the pronotum (see Fig. 7, B) ; but in other respects, as has been seen, the insect retains the same form as before, and continues to run about and feed like the larva. This goes on until the final moult, when the wings are freed from the case enclosing them, and speedily acquire their full size and development.

In the case of the more or less worm-like larvæ (Caterpillars, Grubs, Maggots, &c.), affairs go on very differently. When the larva has acquired its full growth and the last change of skin takes place, the result of this operation is the production of a creature wholly unlike the larva, and generally presenting no more than a distant resemblance to the perfect insect. Where this resemblance is closest, the product of this change of skin is a creature showing the division of the body into the three regions—head, thorax, and abdomen—characteristic of the perfect insect, but which was wholly wanting in the larva ; the legs and antennæ, and the wings in an undeveloped condition are also distinguishable, but all these parts are enclosed in a skin, which closely covers

them, although they are already free and separate from the body. Beetles and Bees and Wasps furnish excellent examples of this condition, in which, although the parts of the future insects are rudely indicated, and often capable of moving a little under irritation, the general characteristic of the insect is a state of absolute repose.

Fig. 8.—LARVA (A), CHRYSALIS (B), AND IMAGO (C) OF PAPILIO MACHAON.

In other instances (such as the Moths and Butterflies) we find that the parts of the mature insect exist in the same way, in an imperfectly developed state, but that they are closely applied to the body within their proper sheaths, and that a continuous case of a more or less horny texture envelops the whole, and renders all the parts incapable of motion, except that the abdomen can generally bend more or less. This outer case follows all the inequalities of the surface produced by the limbs, antennæ, wings, &c., which can thus be distinguished as easily as in the preceding forms. An insect in this condition is commonly denominated a *chrysalis;* it is, of necessity, incapable of moving about or taking nourishment.

As these insects generally pass a considerable time in this helpless and inactive condition, during which the parts of the perfect insects are being brought to maturity within them, the larvæ, before undergoing the change above described, usually select some suitable shelter for the purpose. Many burrow into the ground, and pass the interval of repose in a chamber which secures them from the attacks of enemies and the inclemency of the weather; others seek concealment in sheltered corners, or in the crevices of the bark of trees; others again content themselves with such protection as they can get by adhering closely to the stems or branches, or the under side of the leaves of the plants on which they feed; and not a few, even of those which take up their abode in sheltered situations, spin for themselves a silken cocoon, within which they pass their period of inactivity. In a very large proportion of two-winged flies, the transformation to the second stage takes place within the skin of the larva, which then dries and forms a protective covering for the insect during its period of repose.

The general name *pupæ* is applied to insects in this inactive state, in allusion to the swathed appearance presented by the Moths and Butterflies at this period of their existence, *pupa* being the Latin term for an infant in swaddling cloths. But the same denomination has also been extended to the corresponding stage in the development of those insects which are active throughout their whole life; and thus we get the two categories of active and inactive pupæ, from each of which the insect emerges in the perfect, or, as it is called, the *imago* state. The whole series of changes, here referred to, constitute the *transformations* or *metamorphoses* of insects; and according as the insect is active or inactive in the pupa state, the metamorphosis is said to be imperfect or perfect. It will be seen hereafter that this distinction is of great systematic importance, and that, in tracing the possible genealogy of the class of insects, it is one of the principal matters to be considered. Here, however, we must confine ourselves to such a general exposition of the phenomena of metamorphosis as will suffice to render the subsequent chapters intelligible.

The internal anatomy of insects requires some notice, but it must be passed over very briefly. The idea of a segment, or somite, as it is now frequently termed, implies that of a repetitive succession of parts, that is to say, each somite is to be regarded with certain limitations, as of the same

essential constitution as all the others forming the body. In the Annelids or Ringed Worms this theoretical condition is very nearly realised, that is to say, with the exception of a few modified segments, all the somites of the body are exactly equivalent, at least so far as regards the particular systems of organs which are related to the segmentation. These must necessarily be the organs produced from the outer germinal layer during the development of the embryo in the egg, namely, the integument, in which division into segments is so strongly marked, the central nervous system, and any organs directly connected with the skin. In perfect insects we find the division into segments sufficiently clear, but when we come to the interior the case is frequently very different. But in the larvæ of insects the conditions presented by the worms are almost exactly reproduced; and as, notwithstanding the change of form, there is no denying the individual identity of the perfect Butterfly and its Caterpillar, for example, we must accept the peculiarities presented by the former as produced solely by the modification of parts present in the latter. This applies especially to the central nervous system, which often differs very greatly in the same insect at different stages of its existence.

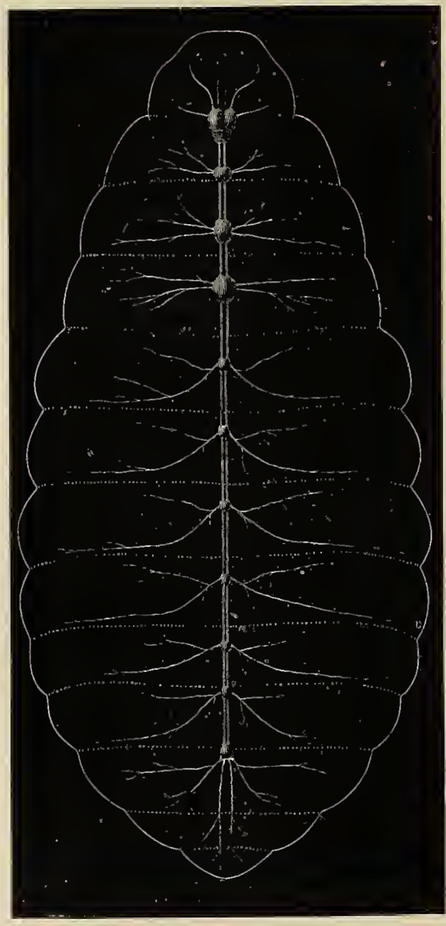


Fig. 9.—NERVOUS SYSTEM OF LARVA OF BEE.

Thus in most larvæ and in many perfect insects we find the central nervous system forming a more or less regular and uniform chain, extending from one end of the body to the other. In the head there are four nervous knots, or *ganglia* as they are called, two of them (which, however, are often united, although even then generally recognisable) situated above the œsophagus, and forming together what is frequently called the brain or the cerebral ganglion; and two, which are almost always amalgamated together, placed beneath the œsophagus. The upper and lower ganglia are united by short nervous cords (*commissures*) on each side, so that the œsophagus is surrounded by a sort of nervous collar or ring, more or less enlarged above and below. From the lower enlargement (that beneath the œsophagus) a pair of slender nervous cords, frequently united to form a single one, run backward into the thorax, and are continued throughout the length of the body, bearing in each segment, until they nearly reach the end of the abdomen, an enlargement or ganglion, which often shows traces of being composed of two halves (Fig. 9). In this way we get a chain of ganglia united by slender commissures, which may amount to eleven in number, exclusive of those in the head, that is to say, one in each segment of the thorax, and eight belonging to the abdomen. The maximum number of body-ganglia thus comes within one of that of the fully developed body-segments. But from this uniform development of the central nervous system, the departures are exceedingly numerous and varied, in relation chiefly to the suppression or amalgamation of the segments in the perfect insects, the general tendency being to shorten the nervous chain, and thus confine the central masses more and more to the anterior part of the body, in accordance with the general direction in which specialisation takes place in this, and indeed in other classes of animals. Thus fusion of the ganglia of the mesothorax and metathorax, or of all the three thoracic ganglia into a single mass, may occur, while the abdominal ganglia still remain separate (Fig. 10); then the latter may unite into a mass which joins the thoracic mass, or the mass formed by the two hinder thoracic ganglia, to constitute a long single central nervous organ in which the original constitution out of separate ganglia is almost wholly obliterated. The nerves which in insects with a regular chain of ganglia issue from

the latter to run to the limbs and to the muscles and other organs of the abdomen, are then given off in a radiating fashion from this elongated nervous mass, those of the abdomen forming a brush-like tuft at the extremity of the consolidated chain.

With a few words upon these nerves we may quit this part of the subject. The upper ganglion of the head (*supraœsophageal* or *cerebral ganglion*) gives off in front a pair of nerves, which run to the antennæ, and above a nerve which goes to the simple eyes or ocelli when these are present, whilst on each side it is directly continued into the thick optic nerves that run to the large compound eyes. The lower, or *subœsophageal ganglion*, furnishes paired nerves which go to the upper lip and the paired organs of the mouth. The thoracic ganglia especially provide the nerves for the wings and legs; and the nerves of the abdomen govern the movements of that part, and especially the function of respiration.

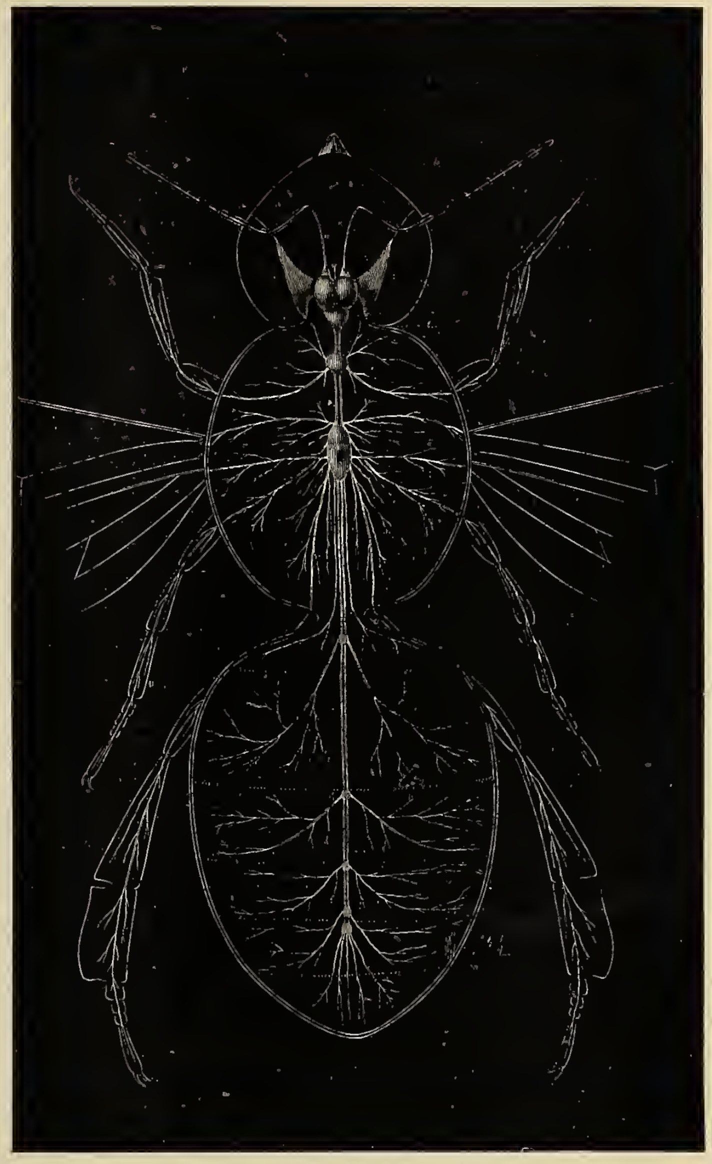


Fig. 10.—NERVOUS SYSTEM OF PERFECT BEE.

The only organs of sense, to which we can with certainty assign a definite function are the *eyes* and *ocelli.* The latter are found as the sole organs of sight in many larvæ, when they are placed in groups on the sides of the head in the position afterwards occupied by the compound eyes. In perfect insects the ocelli are situated on the vertex or crown of the head, and they are then either two or three in number. They are small round organs, showing externally a convex transparent cornea, beneath which is the termination of a nervous branch, specially modified for the purpose of vision. The compound eyes are much larger, and usually very prominent organs situated on the sides of the head, the greater part of the surface of which they occupy in some insects. They may be regarded to a certain extent as composed of a multitude of ocelli, which, in consequence of their being brought as close as possible together, assume a hexagonal form, and thus divide the surface of the composite organ into a number of facets of that shape. Their number is often exceedingly great, but it varies much in different insects. The smallest number recorded is 15 in the eye of a little Bee-parasite; the common House-fly has 4,000, and a species of Dragon-fly as many as 20,000 facets in its eye. Each facet is a small horny lens, usually flat on the outer surface and convex within. The centre of each lens is in contact with the base of a cone, which is frequently regarded as a crystalline body,

but which is really the outer termination of a nervous rod springing from the surface of the expanded end of the optic nerve. The nervous rods and conical bodies are enveloped by a layer of pigment separating them from their fellows. Thus, each of these thousands of facets may be regarded as possessing the structure of a distinct eye (Fig. 11).

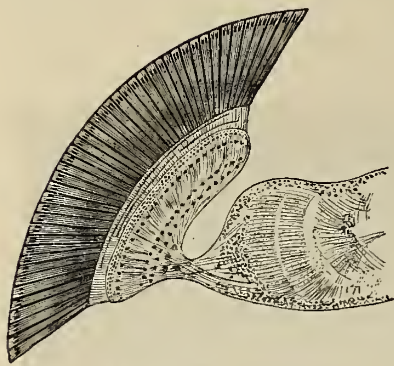


Fig. 11.—STRUCTURE OF EYE OF COCKCHAFER.

The antennæ appear to be the only other organs of sense possessed by insects, but it is exceedingly difficult to ascertain what sense it is their special function to serve, if, indeed, they may not have different offices to perform in different insects. They have been supposed to be organs of hearing and of smell, the former partly on observational grounds, and partly by analogy with the Crustacea; but while we may be certain that insects possess these senses, it is very difficult to point out their seat. The antennæ, however, in some cases, are certainly tactile organs. Special organs of hearing have been described in particular insects by various authors. In the common Grasshoppers they have been supposed to be placed in the sides of the abdomen, in those of another family at the base of the anterior tibiæ. The faculty of hearing has also been assigned to the hind wings of Beetles, and to the halteres of the two-winged flies. The possession of this sense by insects may perhaps safely be predicated from the fact that many of them have the faculty of producing sounds, generally by the friction of the wings, or of the legs against the wings, but in some cases by the agency of special organs.

The digestive organs (Fig. 12) commence by a pharynx attached to the organs of the mouth, and sometimes produced into free processes (*hypopharynx* and *epipharynx*), which especially in sucking insects may take part in the formation of the mouth. This narrows into a gullet or *œsophagus*, which runs through the anterior segments of the body, and becomes widened behind into a first stomach or *crop*. In many sucking insects, this dilatation of the œsophagus is not in the direct course of the alimentary canal, but placed on one side and united with the œsophagus by a narrow canal; it is then known as the *sucking stomach*. The abdominal part of the intestinal canal, presents great differences in different insects and groups of insects. In general in vegetable-feeders the intestine is comparatively simple in its character, but of considerable length and much convoluted; in carnivorous forms, on the other hand, it is shorter and runs more directly to the anal orifice, but is generally divided into several distinct sections, which have received special names. Thus, in many cases we find a *gizzard* (*proventriculus*) a short, more or less spherical, strongly muscular part, the inside of which is often furnished with several horny (chitinous) ridges; and beyond this a much longer and broader *stomach*, of delicate texture, with no chitinous lining, but commonly with a glandular layer, which often gives the surface of the stomach a villous appearance. Beyond this true stomach comes the intestine proper, which often presents a clear division into different regions; and at the point where the stomach and intestine join certain long, slender, blind tubes, known as the *Malpighian vessels*, usually open. These were at one time supposed to represent the liver, but they are now regarded as analogous to the kidneys in the higher animals. Besides these glandular organs we find in the anterior part of the body one or two pairs of salivary glands, which are also blind tubes, sometimes extending back within the abdomen, and not unfrequently possessing a reservoir in the neighbourhood of the mouth. Their secretion is discharged into the mouth during the mastication of the food.

Other glands not connected with the alimentary canal need only a passing notice. Odoriferous glands are not uncommon. They may be situated in various parts of the body, and have their orifices situated in the soft skin uniting the segments or at the joints of the limbs; or in the neighbourhood of the anal orifice, where they produce an acid secretion, which collects in a small vesicle, from which it is ejected as a means of defence. Silk glands are of common occurrence in the larvæ of insects. They consist of a pair of long, blind tubes, placed one on each side of the abdominal region, and communicating by a long duct with an orifice in the labium. The secretion of these glands has the property of hardening into a fine thread when exposed to the

air, and by means of it the larvæ are enabled to form protective coverings for themselves, and especially to prepare the cocoons in which so many of them pass their pupal period of existence.

A considerable portion of the interior of the body of an insect is occupied by a peculiar fatty substance called the *adipose body*, which is especially abundant in the full-grown larvæ, and consists of a yellowish, lobulated mass lining the walls of the body-cavity, and filling up the spaces between the viscera. It would appear to be a store of nutriment to be used up in the final maturation of the insects, as it often diminishes in volume in proportion as the reproductive organs are developed.

The *circulatory apparatus* of insects is sufficiently simple. It consists of a sort of vessel running along the dorsal part of the insect, and divided by constrictions into a series of chambers corresponding in number with the segments of the abdomen, and then continued forward in the form of a simple tubular vessel (*aorta*), through the thorax to the head. The chambered portion part of this *dorsal vessel* is attached to the walls of the abdomen by a series of triangular muscles, which spring in pairs from a broad base on each side of each chamber, becoming narrowed towards the place of their attachment to the skin of the abdomen. The blood within the dorsal vessel is driven forward by the successive contractions of the chambers until it is forced out from the anterior orifice of the aorta, whence it returns through the interspaces of the various organs (*lacunæ*) to the abdomen again. It then passes into the sort of sinus formed around the dorsal vessel by its muscles above described, and thence into the vessel itself through a series of valvular openings between the successive chambers, to be again driven out by the contractions of the organ. There are consequently neither arteries nor veins in the insect-body, and the circulation of the blood is strictly what is called *lacunar*.

Fig. 12.—DIGISTIVE APPARATUS OF DYTICUS.
a, Œsophagus; *c*, Gizzard; *d*, Stomach; *e*, Small Intestine *f*, Large Intestine.

Respiration is effected by means of an immense number of branched tubular organs called *tracheæ*, which communicate with the outer air by a series of peculiar apertures in the integument, known as the *stigmata*. The latter are situated on each side of the body, in the boundaries between the successive segments, but the head is altogether destitute of them, and the last pair of abdominal stigmata are frequently wanting. In the abdomen they are frequently placed in the membrane uniting the dorsal and ventral plates. In form the stigmata are sometimes round, when they are enclosed by a horny ring and furnished internally with bristles or hairs, converging towards the centre to prevent the entrance of injurious particles. In other cases they constitute more or less elongated slits, and are then capable of being closed by a pair of lip-like parts, which also frequently bear spines or bristles, sometimes branched or pectinated. The closure of these stigmata is often effected by the agency of small chitinous pieces imbedded in the membranous parts, which show a singular resemblance to the little bones found in the mammalian ear.

The *tracheæ*, into which these apertures admit the air, are tubular organs, branching through all parts of the body, and gradually diminishing in diameter towards their final ramifications. In this way they convey the air to all the organs, which they, at the same time, bind together and hold in position, thus, to a considerable extent, performing the double office of respiratory organs and

suspensory ligaments. They are cylindrical membranous tubes, within which there is distinguishable a fine annulation, resembling a spiral chitinous thread, and this structure, which is continued into the very finest ramifications of the tracheæ, serves to give them sufficient elasticity to remain constantly open for the free ingress of the air. In general the wide tracheæ, which start directly from the stigmata, run inwards but a short distance, and then open into a longitudinal vessel of the same kind, which passes up the side of the abdomen, uniting all the main stems, and in this way a pair of lateral longitudinal tracheæ are produced, from which the smaller branches going to the various organs are given off; but occasionally the tracheæ from the stigmata run directly into the body. In many insects bladder-like dilatations of parts of the tracheal system occur, and these sometimes form very large air-sacs in the interior of the body; they are of membranous texture, and destitute of the spiral thread, although this makes its appearance again in the fine branches given off from them. Special modifications of this respiratory apparatus are, however, frequent in insects. In many cases, especially in air-breathing aquatic larvæ, the function of the stigmata of the sides of the body is suppressed, and the apertures themselves closed up, and respiration is effected solely by the agency of peculiarly modified stigmatic apertures at one or other extremity of the body. Again, many aquatic larvæ dwell constantly in the water, never coming to the surface to breathe, and, in these, while the structure of the tracheæ remains the same, we find, in place of the stigmata, peculiar organs, which have been called *tracheal gills*, by means of which the insects respire the air dissolved in the water they inhabit. These gills are usually leaf-like organs containing branched tracheæ, and they are sometimes appended to the sides of the abdominal segments, or confined to its posterior extremity.

Reproduction in insects takes places usually by eggs, which are deposited in suitable situations by the females. In many cases they are merely attached singly or in groups to plants or other objects, or deposited in the ground; in other instances they are inserted into the substance of the plant or animal on which the larvæ feed, by the agency of a peculiar organ (*ovipositor*) with which the female is endowed for this purpose; and sometimes the parent insects prepare nests of the most complicated character for the reception of their eggs and the subsequent rearing of their offspring. In some cases, however, the development of the eggs takes place within the body of the mother, and instead of eggs larvæ are then brought forth. A few insects even go farther than this and retain the larvæ within their bodies until they have arrived at maturity, producing their young in the pupa state. These, however, can only be regarded as exceptions to the general rule, according to which the eggs are deposited before any development of the larvæ has taken place within them, and impregnated during their passage outward from the ovary through the oviduct, by contact with the male fertilising element, which has been stored in a special receptacle appended to the oviduct since the union of the sexes. The last-mentioned point is one of considerable importance in connection with the phenomenon of the production of insects from unfecundated eggs (*parthenogenesis*), and especially in the explanation of the constitution of certain societies of insects (such as Ants, Wasps, and Bees). In these it appears to be proved that the male individuals are produced from unfertilised eggs; and in a number of other insects eggs in the same condition have been known to produce larvæ, whilst of some no males have ever been seen, although the insects have been bred for several generations.

In one remarkable group of insects, including the Aphides, or Plant-lice, and some allied forms, reproduction takes place in a peculiar manner, which has been called parthenogenesis, but is really analogous to the so-called "alternation of generations," so frequent among animals much lower in the scale of organisation. In these insects, true male and female forms appear at certain intervals, and the latter produce true eggs; but between the hatching of these and the production of the next true males and females among their progeny several generations of insects succeed one another, which bring forth young by a process analogous to internal budding. The result of this process is sometimes a young living insect, sometimes a more or less egg-like body, and the history of the reproduction of these little creatures is thus rendered exceedingly complicated.

We have now only to indicate briefly the classification that will be adopted in the following pages. By going back over the preceding statements the reader will find that there are two sets of characters, by either of which the class of insects may be divided into two great sections, namely, the characters drawn from the structure of the mouth, that is, whether this is adapted for mastication or for sucking, by which we get the two groups of mandibulate and haustellate insects; and those

derived from the metamorphosis, by which the class may be divided into insects with a perfect metamorphosis, and those with an imperfect metamorphosis or no metamorphosis at all. For many years the former of these methods of division was the one adopted by almost all naturalists, and it has certain advantages in its favour, especially the practical one that, being founded exclusively upon the characters presented by the insects in the perfect state, the student has no occasion to trouble himself about the transformations which they have undergone in order to decide their place in the system. This advantage, however, is more apparent than real, for except in the case of a single so-called order of mandibulate insects the character of the metamorphosis forms part of that of the order; and, on the other hand, there are almost always ample structural distinctions by which the members of the orders can be separated, even without reference to their transformations. Further, taking into consideration the points that have been raised since the resuscitation of the doctrine of the evolution of organic forms by the works of Mr. Darwin and others, it must be admitted that from this point of view the nature of the metamorphosis is of great importance; and for these reasons we adopt a primary division of the class of insects in accordance therewith.

The only difficulty that presents itself more strongly from this point of view than from that of the structure of the mouth is how we are to deal with certain small groups of insects which undergo no metamorphosis at all. These creatures, which are generally of small size and low organisation, may be residues of groups formerly more numerous and abundant, in which case they ought probably to be kept distinct from the other existing orders of insects; or especially in the case of the parasitic forms, which are the most numerous, they may be degraded representatives of the orders to which they appear to be most nearly related. We shall adopt both these views for the different types of insects with no transformations, and arrange the orders as follows:—

I.—INSECTS WITH A PERFECT METAMORPHOSIS.

A. With biting mouths, the mandibles always distinct:—
- 1. Fore wings horny or leathery, forming a pair of sheaths (*elytra*) covering the abdomen and hind wings, and generally meeting in a straight line down the middle . . . . 1. COLEOPTERA.
- 2. All the wings membranous:—
  - *a.* Veins in the wings few; prothorax united with the mesothorax . . 2. HYMENOPTERA.
  - *b.* Veins in the wings numerous; prothorax free . . . . 3. NEUROPTERA.

B. With sucking mouths:—
- 1. Wings four, scaly; maxillæ forming a spiral proboscis . . . . 4. LEPIDOPTERA.
- 2. Wings not more than two:—
  - *a.* Two wings; halteres; thoracic segments united; proboscis formed of the labium, enclosing bristles . . . . . . 5. DIPTERA.
  - *b.* Wings none; thoracic segments distinct . . . . . 6. APHANIPTERA.

II.—INSECTS WITH AN IMPERFECT METAMORPHOSIS OR WITH NONE AT ALL.

A. With sucking mouths; rostrum composed of the jointed labium enclosing bristles . 7. RHYNCHOTA.

B. With biting mouths, of which the parts are exposed; no organs of locomotion at the extremity of the abdomen . . . . 8. ORTHOPTERA.

C. With biting mouths, the parts of which are usually very delicate, and concealed within the cavity of the mouth; no wings; no metamorphosis . . . . . 9. THYSANURA.

By many entomologists the Aphaniptera, or Fleas, are united with the Diptera, or two-winged Flies. Of the insects with no metamorphosis, we have retained the order Thysanura, the members of which have sometimes been united with the Orthoptera; but of the parasitic forms, the true Lice are referred to the Rhynchota, and the Bird-lice (Mallophaga) to the Orthoptera. The Bee parasites, forming the order Strepsiptera of many writers, are placed among the Coleoptera. Some years ago Prof. Westwood founded a distinct order (Achrioptera) for a small insect parasitic on the Canadian Beaver. This has also been shown to belong to Coleoptera. The order Diploglossata, proposed by M. de Saussure, in 1879, for a small African insect resembling a Cockroach, but presenting a second labium, may be referred to the Orthoptera until more is known about it.

W. S. DALLAS.

ORDER COLEOPTERA.

CHAPTER II.

THE BEETLES ORDER—CARNIVOROUS BEETLES.

Definition of the Order—Functions of the Coleoptera in Nature—Total Number of Existing Species—External Structure—Metamorphosis and Early Stages—Instincts—Voice-organs and Organs of Hearing—Hidden Nature of the Haunts of the Majority of the Species of Coleoptera—Nocturnal Habits—Attracted by Light—The Number and Variety of Species swept down by Floods in River-valleys—Fossil Beetles—Section PENTAMERA, Beetles with Five-jointed Tarsi—Tribe ADEPHAGA, or Predaceous Beetles—Family CICINDELIDÆ, or Tiger Beetles—Family CARABIDÆ, Carnivorous Ground Beetles.

THE order Coleoptera embraces that large section of the insect tribes known under the name of Beetles, in which the anterior, or upper, pair of wings are converted into horny covers, or sheaths, meeting in repose in a straight suture down the back, and protecting the posterior, or membranous pair of wings, which, when not in use, lie folded beneath them. Further distinguishing characters are supplied by the mandibulate mouth, adapted for masticating food, and the complete metamorphosis which the individual insects undergo in their growth from the larva to the adult stage. These three important characters, in combination, effectively distinguish all members of the order from the Hemiptera and Orthoptera, which have a superficial resemblance to Beetles in the anterior wings, being also more or less indurated, and serving as protecting covers for the membranous wings. Cockroaches, mistaken for "Blackbeetles" by the ignorant, have scarcely anything in common with the true Beetles, and belong to the order Orthoptera. On the other hand, the Lady-bird, the Turnip-fly, and the Glowworm, in which similar superficial observation is apt to fail to recognise the likeness to Beetles, truly belong to this order. The wingless female of the Common Glowworm, and some few other apterous species, are only cases of arrested or retrograde development.

The compact form and solid integuments which are the rule in Coleoptera adapt them for a far greater diversity of modes of life than is enjoyed by other orders of insects, and especially for plying their vocations in hidden situations; their relative strength and protective armour enabling them to gnaw or force their way out of the interior places where they have passed their larva and pupa stages. They may be said to perform the function in Nature of universal scavengers, chiefly with regard to the smaller quantities of animal and vegetable matter neglected by the larger animals, but not always, their small size and very varied forms and instincts enabling them to attack, by methods impossible to other animals, and to clear from the earth's surface, the carcases even of large quadrupeds and the dead trunks of the largest forest trees. Different groups are organised respectively for terrestrial and aquatic life, and for every shade of variety in each; for living in or feeding on vegetable substances, from the smallest cryptogams, to the root, bark, wood, fruit, and seed of the highest forms of vegetation; and for disposing of excrementitious as well as dead animal substances. All forms of locomotion are displayed; many are specially adapted for burrowing, and for such curious operations as sawing branches or drilling holes in solid wood. There are predaceous groups—terrestrial, arboreal, and aquatic—and groups parasitic on the living bodies of other insects; there are separate sets of alpine, forest, field, and desert forms, in almost every climate, and there is a special Beetle fauna inhabiting the remotest recesses of limestone caverns. In size, Beetles present all gradations, from a length of one-thirtieth of an inch to half a foot.

Such being the wide range in modes of existence, and the consequent diversity of adapted forms, it is not to be wondered at that the number of species of Coleoptera is very large. No fewer, indeed, than 80,000 species have been already described, and all our larger collections contain many that are still unpublished. It is estimated by Professor Westwood that the total number existing in nature is not less than 100,000; this one order of insects is therefore nearly ten times as numerous as the whole class of birds, and more than double the whole of the vertebrata. The classification of the order has been the object of study of many able entomologists since the days of Latreille, who, about seventy years ago, applied the natural system, founded by Jussieu in Botany, to the Insecta. The more recent systematists have grouped the host of forms under seventy-five natural families. In the present work, whilst adopting these well-defined groups, we have, for convenience, restored the larger divisions of Latreille, founded chiefly on the number of joints in the tarsi, or feet, and the form of the antennæ, parts of the mouth and the habits.

The illustration on p. 281 will suffice to explain the divisions of the body of a Coleopterous insect, and the parts of its upper, or dorsal, surface. The insect is represented as divided into four parts, viz., (1) the head; (2) the pro-thorax (bearing the anterior pair of legs); (3) the meso- and metathorax (bearing the intermediate and posterior legs, the wing-covers, and the wings); and (4) the abdomen. This last in the living insect is, however, usually closely attached to the metathorax, forming with it and the mesothorax the so-called "hind body." The mouth consists of a labrum, or upper lip; a mentum, or chin; a lower lip, immediately adjoining the mentum, and two pairs of jaws, viz., the upper, or mandibles, and the lower, or maxillæ; the latter and the labium bearing each a pair of small-jointed appendages called palpi. All these parts are subject to a wide range of modification, which furnishes not only a guide to the food and habits of the insects, but to their classification, the form of the different parts of the mouth being amongst the most constant characters of the genera and families. Throughout all the modifications, however, it is to be noted that the labium, or lower lip, never assumes the form it does in the order Orthoptera, where it shows a division into two lobes, or blades, indicating its fundamental condition, in the lower annulose types, as a third pair of mouth-appendages, bearing the labial palpi on the sides. In Coleoptera, the lower part of the labium is much contracted in size, and the upper part, forming the ligula, or tongue, is an undivided horny or coriaceous plate. This difference is important, as constituting one of the chief signs of the higher specialisation of the Coleopterous order. Besides the mouth, the under-surface of the three segments of the thorax requires the attention of the student. Each segment beneath is normally divided into five parts, or plates, separated from each other by fine sutures, the middle plate protruding a narrow lobe between the articulating cavities, or sockets, of each pair of legs, and the side pieces (two on each side, called episternum and epimeron) being of various shapes according to the genera. The form of these breast-plates, or sternums, especially the various shapes of the processes between the haunches of the legs and the extent to which they take part in forming the rim of the haunch-sockets, constitute most trustworthy guides in ascertaining the natural relationship of the genera and families. The abdomen is composed of a series of rings, or segments, each having its dorsal and its ventral plate, or segment, the spiracles, or breathing-holes, being on or near the points of junction of the two plates. The legs are composed of (1) a haunch, which articulates with the body; (2) a small narrow appendage, on the inner side at its apex, called the trochanter; (3) the femur, or thigh; (4) the tibia, or shank; and, lastly (5), the tarsi, or foot, consisting of a number of joints, differing according to the great primary divisions of the order, and bearing a pair of claws at their tips.

With regard to the stages through which Beetles, like all true insects, have to pass before reaching the winged adult state, we have already said that their development is by complete metamorphosis, that is, the intermediate stage between the active, feeding, larva and the adult, variously called in the different orders, pupa, nymph, or chrysalis, is a period of quiescence, the insect being encased, trunk and limbs, in a membranous or horny integument, and having time and repose sufficient for the elaboration of the great change taking place in nearly all its parts. The metamorphosis, however, is not so complete as in the Lepidoptera (Butterflies and Moths), the swaddling-cloth of the pupa not forming a simple case, but separately covering body and limbs. The larva varies very greatly in form in the different families; it is generally elongated, clothed with a tough skin, and furnished with six feet, in which case it has often a tolerably close resemblance to the perfect insect, minus the wings; but in some large groups it is a footless maggot, and, again, in a few parasitic genera it is an active hexapod in one stage of its growth and a maggot in another. In all its forms, however, it has a distinct head, and thus may be distinguished from the often similar larvæ of Dipterous insects. Viewing the order generally, it may be said that the larva is less unlike the adult and the metamorphosis less complete, than in the Hymenoptera and Lepidoptera, and that the Coleoptera must therefore rank as a less perfect or specialised type than either of those orders of insects.

Amidst all their great diversity of forms and habits, the Coleoptera offer no example of those wonderful social and architectural instincts which excite our admiration in Bees, Wasps, and Ants of the order Hymenoptera, and of White Ants in the Orthoptera. Neither are there any instances of a third, or neuter class of individuals, such as we see in the social species of the above-named orders. No clear case even of co-operation among the individuals of a species is known; the nearest approach

to it, namely, that of the Burying-beetles, many of which are seen engaged together in interring carcases of small mammals, being only the accidental assembly of a number of individuals, generally of different species, each intent on providing independently for its own young, just as a crowd of Geotrupes will work together at a recent cow-dropping, or a swarm of Bark-beetles be attracted to a newly-felled tree. Without reaching this high stage of development of insect intelligence, however, Beetles display instinctive qualities of great perfection and diversity. This is manifested in the arts resorted to by them in entrapping their prey; as in the larva of the Tiger-beetle, which stations itself in a hole it excavates in a sandy bank, and traps incautious flies who tread on the broad head of the insect, that closes the orifice of the hole; and also in the many contrivances adopted by the mother insects for securing a supply of pabulum to their offspring, as in the dung-feeding scarabæi, and the Sitaris, whose habits will be detailed farther on. The extensive prevalence of voice-organs in the male insects of the order is a proof of a considerable amount of understanding between the sexes, the sounds emitted being the calls of the insect to its mate. An excellent *resumé* of this subject is given by Mr. Darwin ("Descent of Man," Vol. I., pp. 378–384). The sounds produced are a kind of stridulation, similar to, but less shrill, than that produced by Crickets and Grasshoppers. Although very diverse in form and situation, the stridulating organs are all on a similar principle, which is that of fiddle and bow, two contiguous parts of the body being mutually adapted for being drawn or rubbed the one across the other. In the great family of Longicorns, the sound is produced by the friction of the hind rim of the prothorax over a finely-ribbed prominence on the mesothorax beneath. These ribs are microscopic, and M. Landois counted as many as 238 on the rasp of *Cerambyx heros*, a common European Longicorn. Many species of this family will stridulate vehemently from alarm, when held tightly between the finger and thumb. The sound is faint in small species, but in the great Harlequin-beetle of tropical America stridulation is so loud that it may be heard at some distance before the insect is seen. In the Necrophori, or Burying-beetles, the organ is situated on the upper surface of the fifth abdominal segment, and consists of two narrow finely-scored bands, which are rubbed by a ridge lying under the apical edge of the shortened wing-covers. In Geotrupes, again, it is the haunches of the posterior legs which bear the fiddle, in the form of a raised band, crossed by fine ribs, across which the hind margin of the third abdominal segment is drawn by a short motion backwards and forwards. These voice-organs exist in both males and females in our common *Geotrupes stercorarius*, as in some other species of Beetles, and the stridulation, therefore, serves both sexes as a mutual call. It appears also to be used in some large species of Stag-beetles as a note of anger or defiance. Some Beetles, on the other hand, produce a sound evidently intended for communication with others of the same species, not by stridulation, but by ticking or rapping, as in the well-known case of the Anobium, or death-tick, which burrows narrow galleries in the wood of old furniture. When performing, the insect fixes itself firmly on its six legs, and then taps against the wood by a series of hammering movements of the whole body, the hard mandibles at each blow coming in contact with the wood. It is easy to induce the Anobium to tick, by imitating the sound with the finger-nail on the wood, when it raps in response.

The existence of sound-organs so curiously elaborated in so many Beetles belonging to different families, implies a corresponding development of the sense of hearing. But although much observation and study have been devoted to this subject, physiologists are not yet in accord as to the situation of the hearing apparatus. The preponderance of opinion seems to be in favour of the antennæ being the ears in the insect class, although the evidence is not yet clear as to the existence of a tympanum at their base. A fine surface sculpture in many of the joints of these organs, which presents itself generally as minute pores, densely pubescent, is supposed to indicate an apparatus for the reception and transmission of acoustic vibrations. In this point of view the minute structure of the antennæ becomes a very interesting study, deserving of more attention than has yet been paid to it, especially as it is constant throughout the minor groups, and offers in those families where it has been attended to excellent characters for natural classification. It is found, on investigation, that the finely-sculptured, pubescent, or porous spaces are not often spread equally over the whole of the organs, but are localised on some few of the joints, and in different situations, according to the species, genera, or groups of genera. According to the celebrated anatomist Landois, the organ of hearing in Stag-beetles is confined to small pits, situated one on each side of the terminal plate of the club. The

sensitive surfaces of the thin plates forming the apical joints of the antennæ of the true Lamellicornia are shown to be of high importance to the economy of the insects, by the care Nature has taken in protecting them. Pits, crowded with sensitive pores, exist very generally throughout the great family Buprestidæ. In Longicorns, where the stridulating organs are so well developed, and the sense of hearing ought to be acute in correspondence, the antennæ are often beautifully sculptured with parallel striæ, but this is chiefly in the male sex, and it is believed that it is the length rather than the texture of the antennæ which in this family adapts them as effective organs of hearing. The Adephagous, or carnivorous families, present a minute porosity and fine pubescence on most of the antennal joints, leaving always a small number of smooth basal ones, the number of smooth joints being of remarkable uniformity in each sub-family or group of sub-families.

A very large proportion of the species of Coleoptera, especially in hot countries, come forth from their hidden feeding-places only after sunset, and a large number pass their whole lives in concealment. Owing to this circumstance, it is only a small minority of the Beetle fauna of any district which meets the eye of the inexperienced naturalist in his mid-day rambles throughout the summer months. This minority consists of such diurnal species as are found on foliage and flowers, or running about over banks and pathways, or on the wing; such species are most abundant in the spring or early summer, the first heats of July sending back to their hiding-places all except those which have by that time provided for the continuance of their species and died. But the bulk of the species are never seen in the open in broad daylight; they have to be sought for in their hidden haunts, amongst vegetable *débris* and garbage of all descriptions, about the roots of herbage, under stones, in and under bark, and in decaying timber, in water rich in aquatic vegetation, in ants' and wasps' nests, in the soil by digging, in the interior of stems of plants, in moss, in manure heaps, under boulders, in the recesses of caverns, and in many other situations where it would seem but little likely they should occur. In tropical countries a large number of species are never seen except on the rare occasions when they fly abroad in sultry evenings at the beginning of the rainy season, at which time they may be attracted by a light placed in front of a sheet or a whitewashed wall. Sometimes their flight is continued far into the night, and if a sudden shower occurs, chilling the air, whilst they are traversing a river or lake, they are cast down by myriads into the water, their half-drowned bodies being cast up by ripples on to the beaches, where a fine harvest of rare species, never otherwise seen, may be gathered by the collector. A similar phenomenon occurs also when sudden floods inundate a river valley, in temperate as well as hot countries. If this happens in the spring, and in a district generally favourable to insect life, the waters sweep down nearly the whole Beetle population from the upper valleys to the lower plains, where, amongst the trees and bushes, every stem and leaf may be seen covered with a miscellaneous crowd, endeavouring to escape from the deluge. The floating *débris* on the water will also swarm with other half-drowned crowds, and when the flood subsides, a little industrious collecting from the sediment stranded on banks, or deposited in trees and hedges, will yield a larger number of species than could be found by ordinary search during a whole summer in the same district.

Before concluding these introductory remarks on the order, a few words may be said regarding fossil Coleoptera. When the highly-specialised structure of Beetles and the absence in the existing creation of connecting links between them and other orders of insects are considered, both of which require long periods of time to bring about, it is not a matter of surprise to find that the type is of great geological antiquity. As far as our present knowledge goes, however, Beetles were preceded in time by the more lowly-organised orders Neuroptera and Orthoptera. The earliest insects known have been found in rocks of the Devonian period in North America, and belong to the Neuroptera. Coleoptera first make their appearance in the subsequent Carboniferous Age; but they seem to be of very rare occurrence, as only two species have been detected, one a Weevil (*Curculioides ansticii*), and the other a Lamellicorn, resembling the existing genus Trox, and named *Troxites germari*. That these earliest of all known forms should belong to two of the most highly organised families of the order is a matter for legitimate surprise; and the fact is only to be explained on the hypothesis, in which all modern biologists are agreed, that our oldest fossiliferous strata are far more recent in date than the origin of life, or even the commencement of differentiation of the orders in the lower classes of the animal kingdom. Later on, in the secondary

period, Coleoptera are found in the Lias in some abundance, and of such definite forms that they have been referred without hesitation to many of the modern families—Carabidæ, Gyrinidæ, Hydrophilidæ, Scarabæidæ, and so forth; in the lower marls of the Lias in the Swiss Alps no fewer than thirty-three species of Buprestidæ have been found, two of them supposed to belong to genera which still exist. The resemblance to existing genera is carried still farther in the Oolite and in the Upper Eocene; and in the Lower Miocene it becomes so close that the numerous Beetle fossils found in beds of this formation in Central Europe belong for the most part to genera which still inhabit the same countries.

SECTION I.—PENTAMERA. BEETLES WITH FIVE-JOINTED TARSI.

TRIBE ADEPHAGA.

The first tribe of the order Coleoptera, or the Adephaga, is distinguished from all others by an organisation specially adapted to carnivorous and predaceous habits. The general form of body is slender, the three chief segments—head, prothorax, and hinder-body—having free play, and the limbs are constructed for rapid locomotion. All have five joints to the tarsi; the haunches of the first two pair of legs are rounded, and move in rounded sockets; the abdomen beneath is composed of six or seven segments, of which the first three are soldered together; and the antennæ are always slender and light, being thread-shaped, or tapering to the apex, composed of eleven sub-cylindrical joints, and never club-shaped at the tip. But the chief points of distinction from other tribes reside in the parts of their mouth, as in the analogous case of the dentition-characters of the order Carnivora in the Mammalia. The maxillæ are horny and generally hooked, forming a second pair of instruments for cutting and tearing, and their outer lobes are transformed into an additional or third pair of palpi. The mentum, or chin, is always well developed, and of definite form and outline, being horny throughout, with a free upper margin, excised in the middle, and often armed in the centre of the angular excision with a tooth. From its upper inner edge rises the ligula, or tongue, generally an oblong and angular horny plate, flanked by the adherent slender paraglossæ, and fronted at its base by the labial palpi. The Adephaga are distinguished generally from all other sections of the order by the sharply-defined form of all the parts of the mouth, and the ease with which they may be examined. Within the limits sketched out by the above characters, they are subject, as well as other parts of the structure of the insect, to great modification, in correspondence with the greatly-diversified modes of life of the countless members of the group. The section is composed of four families, viz., Cicindelidæ, Carabidæ, Dyticidæ, and Gyrinidæ, which are re-combined by many authors under two sub-sections according to their mode of life; one named Geodephaga, or Land-beetles, comprising the first two families; the other Hydradephaga, or Water-beetles, including the last two.

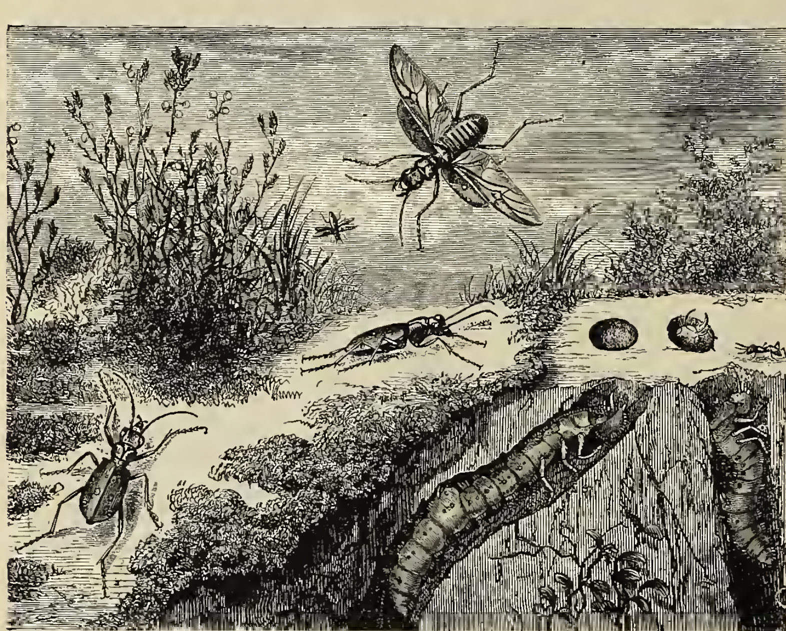
FAMILY CICINDELIDÆ, OR TIGER-BEETLES.

Cicindelidæ are the elegantly-formed and nimble insects known popularly as "Tiger-beetles." The raptorial type of structure is in them carried to a high degree of perfection. Their eyes are large and prominent, and all their movements show extreme wariness. Most of them make ready use of their wings in flying, besides being endowed with remarkable speed of foot, and their mouths are well adapted for seizing and retaining their prey, their mandibles, or upper jaws, being long, and furnished with numerous sharp teeth, and their maxillæ and palpi studded with rigid bristles, which retain from the sides and beneath anything transfixed by the mandibles. With regard to other organs of the mouth, they differ from Carabidæ in the greatly diminished size of the lower lip, which does not project beyond the edge of the mentum, and in the basal support of the labial palpi being articulated, forming a fourth joint. These lip-palpi, in fact, from their length, and, in many cases, the width of their joints, added to the rows of bristles with which they are furnished, supply the place of the mentum, in closing the orifice of the mouth from below, thus furnishing one of those cases of compensation which are so frequently observed in insect structure and functions. The last feature in the mouth-structure which we need notice is the articulated horny hook at the apex of the maxillæ, which distinguishes nearly the whole of the family from all other members of the section, in which the hook or point is simply the terminal portion of the blade.

The number of species of Tiger-beetles at present known is not much less than 1,000, classified under five sub-families and about forty genera. They are found in all the warmer parts of the earth, with the exception of oceanic islands; and some species range as far north as Lapland. The majority

COLEOPTERA ESCAPING FROM A RIVER-FLOOD.

frequent sunny banks and bare places having a light soil, such as sandy sea-shores, banks of rivers, and pathways on heaths and in woods. Here they hunt their prey, and pass through their earlier stages, the larvæ, soon after being hatched in the warm soil, burrowing deep cylindrical galleries more or less vertical, in which they conceal themselves, their broad heads, armed with long mandibles, closing the orifice and entrapping any unwary insect which falls in their way. Four species of true Cicindela are found in the British Islands, the commonest of which (*Cicindela campestris*), abundant in the southern counties, may be taken as a fair sample of the whole family. It is of a beautiful light green colour, with opaque shagreened surface, the underside and legs having a brilliant coppery and golden lustre. The elytra bear traces, in a number of small, whitish spots, of the characteristic markings of the family, which occur in nearly the same position, but endlessly varied, in hundreds of its species, and most frequently form a flexuous band across the middle, with crescent-shaped spots at the shoulders and the apex. The bands are represented in *Cicindela campestris* by detached spots only, which lie in the position of the ends, or angles, of the bands and "lunules," as the crescent-shaped markings are termed; but in Central and South-Eastern Europe varieties of our English species occur in which the middle spots are linked together by a white band across each wing-case, showing that these different patterns are but modifications of one type. The other British species are *Cicindela sylvatica*, found only on heaths in the southern counties; *Cicindela maritima*, occurring on sandy sea-shores in the east and south, and as a distinct local variety in Lancashire; and *Cicindela germanica*, which has been met with only in a few localities in the south of England.

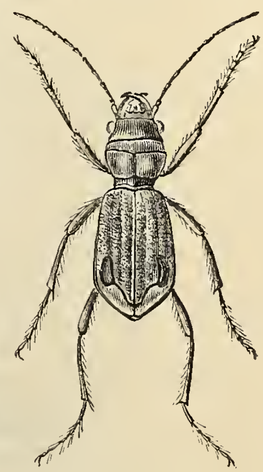


CICINDELA CAMPESTRIS AND LARVÆ.

The genus Cicindela comprises more than half the species of the entire family. With the exception that some of the species found on sandy shores in tropical and sub-tropical regions have the legs developed to an extraordinary degree of length and tenuity, and that in others the white markings are so greatly extended as to cover the whole surface of the elytra, there is no very wide difference either in form or colouring between them and our native species. The largest and handsomest are the richly-coloured *Cicindela chinensis*, abundant in rice-fields in China and Japan, and *Cicindela octoguttata*, an inch in length, a native of Assam. Some of the smaller species at times occur in immense numbers on pathways in hot countries, rising like swarms of flies as one walks along the streets of a tropical village.

The other genera recede more in habits than in form from the typical Cicindelæ. Thus the *Odontochilæ*, slender, dark-bronzed forms, are found only in the shade of tropical forests; the *Oxygoniæ*, most resplendent in colouring, fly and run about mossy boulders in mountain-torrents of the Andes; the *Hiresiæ*, of tropical America, and the *Therates*, *Collyrides*, and *Tricondylæ*, of tropical Asia and the islands of the Malay Archipelago—in all which the prominence of the eyes is carried to an extreme—are arboreal insects, running and flying after their prey along the branches and over the trunks of trees in the virgin forests. The *Phæoxanthæ*, a species of which (*Phæoxantha klugii*) is represented in our engraving, are remarkable in being nocturnal insects. They make very little use

of their wings, but are extremely swift runners, coursing in serpentine motion over the smooth sand-banks of rivers in South America; the species are all of pallid, clayey-white hues, and the burrows of their larvæ reach a depth of two feet in the sand, the perfect insects concealing themselves during the day in similar burrows. The antennæ are longer and thinner in these interesting insects than in the typical sun-loving genera of the family. In this and other respects they resemble the brilliant metallic-coloured *Tetrachæ*, some of which also seek their prey at night, but they do not abstract themselves so completely from the daylight as do their pallid relatives, the Phæoxanthæ. The genus Tetracha occurs in the Mediterranean region, in Australia, and in tropical and temperate America. The only other Tiger-beetle forms we need mention are the *Manticoræ* and their allies, the giants of the family. They are distinguished by their uniform black colour and the absence of wings, and are found in the extensive sandy districts of South Africa (where the largest, the true *Manticoræ*, resembling huge black spiders, occur), in California (the genus *Omus*), and at the eastern foot of the Rocky Mountains, which is the home of the *Amblychila cylindriformis*, an insect formerly of extreme rarity, but which has recently been taken by American entomologists in great abundance under wet hides, laid as traps on the ground over-night. An isolated form of this sub-family, the *Agrius fallaciosus*, is found at Sandy Point, in the Strait of Magellan.


PHÆOXANTHA KLUGII.

FAMILY CARABIDÆ, OR CARNIVOROUS GROUND-BEETLES.

The second family (*Carabidæ*) is distinguished from the Tiger-beetles by the general form, or *facies*, of its species, and by slight modifications, difficult to make clear by description, rather than by definite structural characters. All the apparent peculiarities of the external anatomy, such as the simple anterior tibiæ, many-toothed mandibles, atrophied labium, jointed apex of maxillæ, &c., are repeated in some few of the genera of Carabidæ. These genera belong to the first, or less numerous, division. In the great bulk of the family, forming the second division, the notch on the inner edge of the anterior tibiæ and the sensitive pubescent surface of the basal joints of the antennæ, of which only two or three joints remain polished, supply effective points of distinction. Bearing this in mind, the student will never be in a difficulty in assigning a doubtful species to its right family. In Carabidæ, the style of coloration and markings of the Tiger-beetle is nowhere seen; nor do the mandibles, even when long and toothed, as they are in some few genera, assume the slender curved form and sharp dentition characteristic of that family; other minor differences are the narrower and simpler upper lip and less prominent eyes.

Although the habits of the Carabidæ are very varied, there is not much diversity in the forms assumed in their early stages, or in their transformations. With few exceptions, the larvæ conform to a simple type, having elongated bodies, tapering behind, furnished with six legs and a horny plate on each of the thirteen segments, the thoracic segments being more horny, but not much differing in shape from the rest. The head is of oval form, and the opening of the mouth small, showing that their food must be taken in small and semi-fluid particles. The upper jaws, like those of the perfect insects, are much smaller than in the Tiger-beetles; and the eyes are six in number on each side, disposed in two rows immediately below the short antennæ. They inhabit generally the same situations as the perfect insects; and both are often seen together in the sheltered and dark places where they seek their prey, such as under stones or logs of wood, about the roots of herbage, in moss, among dead leaves, or under loose bark of trees. Some species have the anomalous habit of feeding on vegetable substances; at least, this is indubitably the case with the larva and perfect insect of *Zabrus gibbus*, a dark bronzed species of the *Pterostichini* sub-family, of oblong, heavy build, found in great abundance in Central Europe, and less commonly in England. It frequents wheat-fields, and devours the grain, proving in some years very destructive in France and Germany. Vegetable-feeding propensities have also been suspected in other genera, such as Amara ("Sun-beetles," allied to Zabrus), Ditomus, and some species of *Harpalus*.

The number of species of Carabidæ at present known is not less than 10,000; and they appear

to occur everywhere on the land-surface of the earth where life exists at all—in the most desert places of the tropics, in the Arctic regions, up to the line of perpetual snow on mountains, and in the deepest recesses of limestone caverns (*Anophthalmi* and others), where, for countless generations deprived of the merest glimmer of daylight, a numerous tribe are found completely blind, and with all traces of eyes obliterated. They are well represented on the remotest oceanic islands, generally in species and genera curiously modified from all known forms of the nearest continents. Some genera of very minute species (*Scotodipnus* and *Anillus*) have been discovered underneath huge secular boulders, embedded many feet deep in the earth, and requiring crowbars and the strong arms of labouring men to overturn in order that they may be reached. In temperate latitudes the great majority of the species are ground-beetles, at most hiding themselves in moss or under stones;

CARABUS AURATUS.

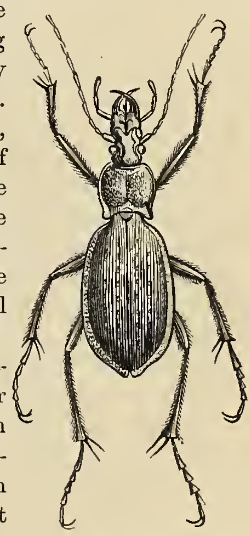
many genera, however (*Scaritinæ*), are diggers, being furnished with strong, palmated fore-shanks (analogous to those of the Mole-cricket) to suit their fossorial habits, and thus being enabled to burrow to considerable depths in the soil to get at their special prey, the small insects which infest the roots of shrubs. But in tropical countries, more especially in the plains, where the functions of insect scavengers, on and immediately under the soil, are almost monopolised by the ubiquitous ants, ground Carabidæ are much less numerous, at least, in individuals. In these climates the majority of the native species of the family live on trees. These arboreal species are more varied in their forms, offer more peculiarities of structure, and are usually more beautifully-coloured and marked than the ground species; they exhibit also interesting modifications of structure suitable to their habits, the tarsi, or jointed feet, being often lobed, and their claws elegantly toothed, to enable them to cling to the edges or surface of leaves. Those which live under the rotting bark of huge forest trees have, instead of the adapted feet, flattened bodies, enabling them to penetrate narrow crevices, and the parts of the mouth are in some cases also prolonged and flattened, the better to enable them to seize their prey in such situations.

Like most other families of Coleoptera, but perhaps in greater degree than any other, the Carabidæ

readily assume the dormant condition; this enables them to withstand extremes of temperature, and to flourish in a great diversity of climates and situations. In cold climates their favourite winter retreat is in beds of moss; and they may be found in numbers in England in such situations, on sloping banks and at the foot of trees, where moisture does not accumulate, throughout the winter. On the other hand, in arid, sandy tracts in Australia and Africa, where so many fine species occur, they no doubt pass the great heats of the dry season in burrows or sheltered places at the roots of brushwood, for they are quite as sensitive to heat as they are to cold. Even in cool countries like Britain they are very rarely seen abroad in hot and dry summer weather; and in the tropics, during the many months of the dry season, they all disappear, to come forth only with the return of the rains.

The means of defence from their enemies possessed by the Carabidæ are less varied than in most other families of Beetles. They have generally great speed of foot, and many of them take wing readily enough, or conceal themselves rapidly among herbage, but cases of protective disguises or mimicry are unknown or very doubtful; this applies even to the simplest form of disguise, assimilation of form and colour to the material of their surroundings. This deficiency seems to be made good by the faculty which they possess of secreting an acrid, or fœtid, liquid from the anus, which is effected by means of special glands. The liquid is ejected sometimes with force when the insect is handled; and in one well-known group—the *Brachini*—the secretion is volatilised, and issues forth as a little cloud of smoke. The *Brachinus crepitans*, a common insect under stones in the South of England, has been observed to discharge its singular weapon when pursued by an insect enemy; and it derives from this habit its popula rname of "Artillery-beetle." A slight sound is sometimes audible when one of the Beetles fires its mimic gun whilst held in the fingers. The explosion and its effects are, however, very much stronger in some of the large exotic species, such as the South American *Pherosophus complanatus*, which, when caught, will often crepitate quite loudly several times in succession, and cause a burning sensation in the fingers, which are stained brown where the vapour has touched them.

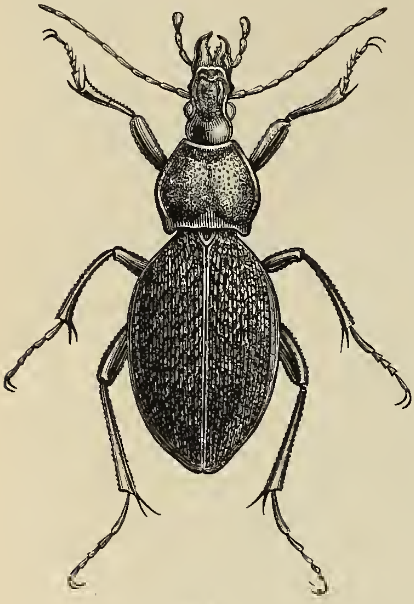
The vast host of specific forms of which the family Carabidæ is composed group themselves naturally under two divisions, founded on an important difference in the framework of the sternum, or breast. The difference is this: in one set of forms, constituting the first division, the hindmost of the three side-plates of the middle thorax (mesothoracic epimera) reach inwardly to the sockets of the haunches of the middle pair of legs; in the other set, forming the second division, they stop short, so that the orbit of the sockets is tightly closed by the meeting of the central-plates of the middle and hind thorax. Although the physiological importance of this difference can be only small, perhaps tending to a little more compactness of structure and precision of movement in the one form than in the other, the morphological significance is very great, for it is found that all the genera allied in other respects to the two neighbouring families, Cicindelidæ and Dyticidæ, belong to the first division, and all the highly specialised forms of pure Carabideous type belong to the second. The forms of the first division are therefore nearer the fundamental common type of the Adephaga than those of the second.



CARABUS ADONIS.

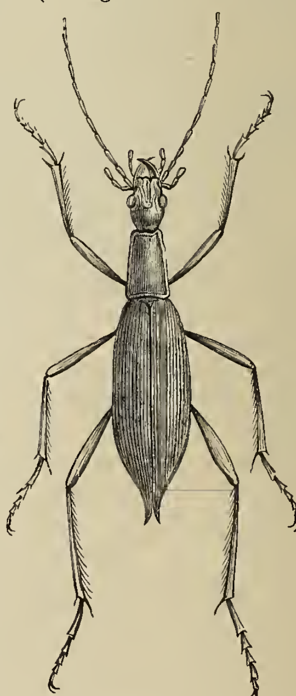
The first division is well represented in temperate latitudes. It comprehends all the true *Carabi* and the *Calosomæ*, large insects, remarkable for their generally brilliant metallic colours and elegant sculpture, the elytra being often scored with fine punctured lines, between raised interstices, which are consolidated in some species into a smaller number of rib-like elevations, and again in others are broken up into rows of tubercles. Of the genus *Carabus*, about 400 species are known. A good idea of their form may be gathered from our illustrations, in one of which are represented two individuals of *Carabus auratus*, a common French species, sometimes found on our southern coasts. One of the Beetles is engaged in disembowelling a Cockchafer, whilst one of the two larvæ figured is seizing an Ant. Our other illustration represents *Carabus adonis*, a large species of a rich violet colour, with golden borders to the wing-cases, which is found only on the classical Mount Olympus, in Thessaly.

The geographical distribution of the genus is remarkable. It is restricted, with the exception of one small group of species, to the north temperate zone, Southern Europe and Western Asia yielding the most species, and North America relatively the fewest. The single exception to this northern range is Chili, in the southern and coldest provinces of which, as far as the Strait of Magellan, a few species are found, of great splendour of colouring and elegance of form, constituting a sub-genus. The interval which separates this outlying antarctic colony from the northern main body has a width of seventy degrees of latitude, no species of Carabus having yet been met with in tropical America, nor, in the Eastern Hemisphere, in tropical Asia, South Africa, or Australia. The species are very numerous and varied in mountain ranges, the Caucasus, Pyrenees, Alps, and Altai being very abundantly stocked; a few remarkable species are also found in the Atlas range, and in the Himalaya and mountains of Southern and Western China. The genus is also remarkable for the extraordinary variability of its specific forms, the variations being often confined to definite localities, and tending to the formation of sub-species and representative species.



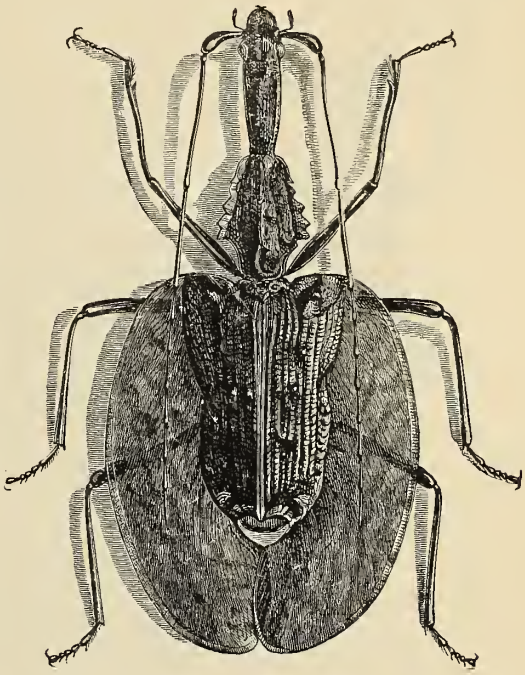
PROCERUS GIGAS

Carabus proper is the centre of a group of genera, some of which contain insects of very large size. Such is *Procerus* (of one species of which, *P. gigas*, we present a figure), containing a small number of bright blue and violet species, restricted to South-eastern Europe and Asia Minor. Another is Damaster (see figure of *Damaster blaptoïdes*), an eccentric form called the "fiddle-beetle" by the Japanese, to whose country the genus is confined. *Calosoma*, a genus almost as handsome as *Carabus*, is distributed over tropical and south temperate as well as northern regions, but does not reach very high latitudes or great alpine elevations. Some of the species have the remarkable habit of climbing trees in search of caterpillars, which constitute their prey. *Nebria* is a numerous genus, of smaller size and slighter build, restricted to temperate and arctic latitudes, and *Elaphrus*, having a similar geographical distribution, is remarkable for its prominent eyes, like the Tiger-beetles, towards which family the genus is certainly an approximation; the species, of which four are found in Britain, are marsh insects, and are found running over damp earth in the sunny days of early spring. Among the exotic forms of this section, the most extraordinary is *Amphizoa*, found in the valley of the Sacramento, in California. In the structure of its sternum and haunch-sockets, and in its naked antennæ, it resembles the true Dyticidæ much more closely than any form of Carabidæ, but its legs are formed for running, not swimming. Its place in a natural arrangement seems to be at the commencement, indifferently, of the two chief families of the tribe, indicating that it is a survival of some primitive form from which these families have branched by subsequent evolution. Another remarkable group are the *Ozæninæ*, medium-sized Carabidæ, found in tropical and warm countries at the roots of plants or under the bark of trees. They have a small fold in the outer margin of the wing-covers, a feature which is observed elsewhere in no group but the very aberrant family *Paussidæ*, described farther on. The numerous sub-family *Scaritidæ*, or burrowing Carabidæ, belong also to this first division, as do also the allied group *Siagoninæ*, found chiefly in sandy districts round the Mediterranean. One significant character of the division is the disconnection which exists between the various sub-families



DAMASTER BLAPTOÏDES.

of which it is composed and the number of isolated forms it contains. One of these latter, the last we shall notice, is the *Mormolyce phyllodes*, which has no near allies (except two or three other species of the same genus) in the whole family, and looks like a monstrosity. It is found only in the Malayan Peninsula and the neighbouring large islands. It will be noticed, on examining our figure of this insect, that its anomalous form is chiefly due to the great expansion of the side borders of the wing-cases, and their prolongation in a curve beyond the ordinary termination of these members. Count Castelnau, who observed the habits of this extraordinary Beetle in its native forests, and who discovered two new species of the genus, says that it is found clinging to the under surface, close to the ground, of trunks of the largest trees, when these have been uprooted by storms, and that he never detected it under the bark, although its very flattened and expanded form seems to adapt it for such a habit. It probably preys on the larvæ and pupa of insects infesting the boleti, with which damp bark is generally covered.



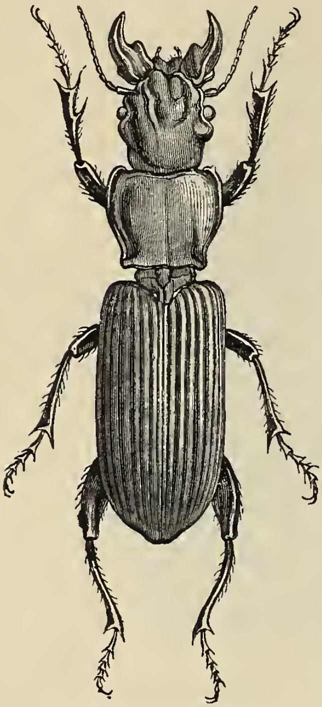
MORMOLYCE PHYLLODES.

The second division of Carabidæ, or that in which the hindmost plates of the middle thorax do not reach the sockets of the haunches of the second pair of legs, is much more numerous in genera and species than the first division, but it is at the same time less diversified in its essential structural characters. It may be remarked also that its sub-families and genera are less strongly differentiated from each other, a phenomenon which can only be explained by assuming that there has been less extinction of intermediate forms, and that the type is posterior to the type of the first division in time and in grade of evolution. This assumption is confirmed by the study of other peculiarities in their organisation already noticed, namely, the notched anterior shanks and the fewer number of finely pubescent or sensitive basal joints of the antennæ, special features which do not re-appear in any other group of the Adephaga.

TEFFLUS MEGERLEI.

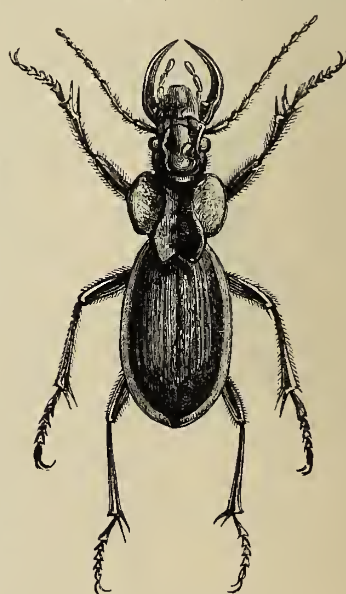
The male insects in this division are distinguished (as they are also in most genera of the preceding) by the feet of the anterior pair of legs being dilated, and the under surface of the expanded joints being furnished with a pad of short hairs or scales. The function of these dilated palms is to secure the hold on the female at the time of pairing, additional grasping or adhesive power being rendered necessary by the prevailing polished surface of the integument in this family of insects. They have been likened to hands, and Latreille, in drawing up his natural classification of the group, named the subordinate sections *Patellimani*, *Quadrimani*, *Simplicimani*, according to the shape and number of the "hands," and the clothing of the palms, some groups having one and others two pairs of dilated feet, and some having palms clothed with a smooth flat brush of hairs, whilst in others the hairs are replaced by ragged cartilaginous scales generally arranged in rows. These peculiarities form very constant characters, and are of great value in the classification of the family. It may be remarked that whenever the males have dilated feet in the first division (*e.g.*, in the Tiger-beetles), the palms are clothed with a plane brush of hairs; the modification into scales appears first in the second division, and in the most specialised forms.

There are about 600 tolerably well-defined genera in this second division of Carabidæ, grouped under a proportionally large number of sub-families. Our space permits us only to allude to a few of the most remarkable forms of this immense assemblage. The starting point of the division is formed by the sub-family *Broscini*, a group resembling the Scaritinæ of the first division in the thorax being separated from the elytra by a peduncle, formed by the exposed narrow mesothorax. The great majority of the species belong to the Southern Hemisphere, in New Zealand, Australia, and Chili. One (*Broscus cephalotes*) is a well-known British Beetle, found under *débris* on sandy sea-shores. Another conspicuous sub-family is the Panagæinæ, belonging to the "Patellimani," the first pair of feet in the males in the principal species having two or three joints dilated in the form of a platter. They prefer situations having a light sandy soil, and are distinguished by their minutely-sculptured roughened surface, and generally by the ornamental marking of their wing-cases, consisting of four bright red square spots, so arranged that the ground colour between them forms a black cross. *Panagæus crux-major* is a well-known British species. A gigantic black or metallic-coloured form of the Panagæidæ is the genus Tefflus, found in numerous species in tropical Africa, in which region the red-spotted species also occur in great variety. Next to these come the Licininæ and Chlæniinæ sub-families. The Chlæniinæ inhabit marshy places, and the margins of streams and pools. They are mostly of beautiful metallic colours, with elytra clothed with soft silky pile. Upwards of 400 species are known from nearly all parts of the world, tropical and temperate, and several are found in the British islands. The *Anchomeninæ* and *Pterostichinæ*, which next follow, contain the most abundant and widely-distributed Beetles of the whole family, and include the common Black-beetles of our pathways (*Steropus madidus, Omaseus vulgaris*), and the little oval bronzed Sun-beetles (*Amara*) seen so commonly running along pathways in spring. Australia is exceedingly rich in genera and species of Pterostichiinæ, and it is there that occurs the largest species of the sub-family, the Hyperion Schrœteri of our illustration, two inches and a half long. In all the above the number of smooth, non-sensitive basal joints of the antennæ is three; in another series of sub-families there are only two; among these are the Harpalinæ, and the Anisodactylinæ, which have dilated palms to the four anterior feet of the males.



HYPERION SCHRŒTERI.

The last, or highest, sub-families of the division are those containing all the principal arboreal groups. But whether terrestrial or arboreal they may be recognised by the wing-cases being clipped short, or truncated, at their apices; hence the name of Truncatipennæ applied to the whole series. The genera are excessively numerous and varied, and the great majority are found only in richly wooded regions, chiefly in the tropical and sub-tropical zones of the earth. Most are of small or medium size, and of light graceful shape. The Lebiinæ, which constitute one of the groups, and are tolerably well represented in Europe and in our own country, are extremely numerous in tropical America, where they live on low trees, and run with great ease and rapidity over the smooth broad leaves of *Heliconiæ* and other broad-leaved plants in moist situations. The *Callidinæ*, larger and more linear in form, are another numerous group, but foreign to Europe; they are more exclusively arboreal than the Lebiinæ, and one of their genera, the *Agræ*, are remarkable insects with narrow and elongated head, and thorax,



ANTHIA THORACICA.

which live entirely on trees, and seek their prey at night, remaining during the day concealed in the folds of curled-up leaves. One large section of Truncatipennæ, however, are terrestrial insects, such as the Artillery-beetles (Brachininæ), Odacanthinæ, and other sub-families, and another (Coptoderinæ, Thyreopterinæ) are bark-insects, *i.e.*, specially adapted for seeking their prey upon or underneath the bark of trees, where lignivorous and fungivorous insects of other tribes abound. The feet of these are not lobed, but their claws are in many genera finely toothed, a structure which enables them to maintain their foothold in running over the bark. Many run with great speed, and, owing to their flattened forms, slip with facility under slightly-loosened bark in pursuit of their prey. A large number of brilliantly-coloured and prettily-marked species, belonging to these sub-families, inhabit the forests of tropical countries.

Among the remaining families of *Truncatipennæ*, the most conspicuous insects for size, strength, and truculent aspect are the Anthiæ, which abound in open districts in most parts of Africa. They are essentially runners, their wings being rudimentary or absent, and they are reported to seek their prey with great activity among low bushes and herbage in sandy places. The truncature of the wing-covers is sometimes scarcely perceptible in this group. More than 100 species are known, grouped under eight genera. Our illustration represents a species common in South Africa, especially in Natal.

CHAPTER III.

CARNIVOROUS, ANOMALOUS, AND BURYING-BEETLES.

Pentamera (*continued*)—Family Dyticidæ, or Carnivorous Water-Beetles—Air-breathing Insects—Peculiar Mode of Respiration—Structure, Transformations, and Habits—Family Gyrinidæ, or Whirligig Beetles—Curious Mode of Progression on the Surface of the Water explained—Family Paussidæ—Grotesque Forms—Kept as Involuntary Guests of Ants—Tribe Palpicornia—Family Hydrophilidæ, Herbivorous Water-Beetles—Carnivorous Habits of the Larvæ—Families Georryssidæ, Parnidæ, and Heteroceridæ—Mode of Breathing by Air-bubbles carried beneath the Water by the *Parni*—Tribe Brachelytra: Family Staphylinidæ—Low Type of Structure—Families Pselaphidæ and Scydmænidæ—Blind Pselaphidæ, the Pets of Ants—Tribe Necrophaga or Clavicornia—Heterogeneous Composition of the Tribe—Family Silphidæ—Burying Beetles, and their Singular Habits—Families Trichopterygidæ, Scaphidiidæ, Phalacridæ, and Nitidulidæ—The Smallest Beetles known—Families Trogositidæ to Histeridæ—End of the Necrophaga.

FAMILY DYTICIDÆ.

The Dyticidæ are predaceous Beetles of the water, differing from Carabidæ chiefly in their legs, and the shape of their bodies being modified to suit their aquatic life. The oval, or boat-like, and compact general form and oar-shaped hind legs of the typical species are familiar to all young naturalists, as many species are amongst the most common living objects of our ponds and slow-flowing rivers. The principal other points in which they differ from Carabidæ are, (1) their smooth antennæ, destitute of minute sculpture and fine pubescence, which constitute the sensitive surface in those organs; (2) the greater development and more solid texture of their ligula, or tongue; and (3) the larger dimensions of the coxæ of their hind legs, which are in the typical genera soldered to the voluminous metasternum, or hind portion of the breast. With regard to these differences, it may be said that the smoothness of the antennæ is a necessary condition of their aquatic life, as a hairy surface under water would interfere with the free transmission of impressions through the organs, by the collection of air-bubbles on their surface. The great development of the hind coxæ, their consolidation with the metasternum, and the great volume of the latter, are in similar manner correlated to the increased work thrown on the hind legs, as oars, in propelling the insect through the denser element of water, stronger muscles, with firmer attachment surfaces, necessitating increased size and firmness of the segments of the body to which their legs are articulated.

Dyticidæ are most abundant in stagnant waters. When inactive, or hibernating, they conceal themselves in the thick tufts of aquatic herbage, or in the soft mud. They become active in the early spring, and may then be seen moving in the water by the propulsion of their strong hind legs, and coming at intervals to the surface to breathe. This function, indispensable to them as air-breathing animals, is performed by elevating the tips of their bodies on arriving at the surface, and taking in a supply of air, for the stigmatic openings of their abdomen and thorax, under the tips of their wing-

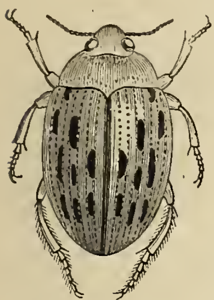
covers ; the anal segments of the body being depressed for the freer passage of the air. They are able to make good use of their wings, leaving the water and flying to distant ponds in fine summer evenings. For defensive purposes, they have the same faculty as the Carabidæ of emitting a fetid liquid, but where this has been observed it is not, as in Carabidæ, by the anus, but through the interval between the head and the thorax.

The larvæ, more voracious and fiercer in aspect than the adult insects, are hatched from the cylindrical eggs in early spring and in autumn. They are of similar general form to the larvæ of the Carabidæ, and differ from the perfect insects in their heads, as well as the other parts of their long bodies, being free and mobile. Their mouths are armed with long and sharp sickle-shaped mandibles, well adapted to seize their prey, which consists of the larvæ of other insects, even of their own species, fresh-water molluscs, and sometimes young fishes. They quit the water to undergo their transformations, excavating a chamber in the soil, in which they pass into the pupa stage, emerging in due time as adult beetles.

The family includes two distinct sub-types, which some recent authors are inclined to treat as separate families. In the one (*Haliplinæ*), consisting of species of small, or minute size, some of the essential peculiarities of Dyticidæ are wanting, such as the natatory hind legs, which do not differ in form from those of many Carabidæ. The posterior haunches, in correlation, are also not enlarged in front, although differing from those of Carabidæ in other respects. A still more important differential character has been recently discovered by Dr. D. Sharp, namely, in the relations of the chief side-plate of the metasternum to the sockets of the haunches of the middle pair of legs. This piece

DYTICUS MARGINALIS.

(episternum) in the great majority of the true Dyticidæ is extended so as to form part of the orbit of the socket; but in Haliplinæ, as in all the Carabidæ, it is not. The Haliplinæ are, notwithstanding, essentially Water-beetles, and cannot be classed with the Carabidæ; they swim freely, though somewhat slowly and with an ambulatory motion through the water, and their hind legs, although not compressed and flattened into oar-like organs, are furnished with a fringe of long hairs, unlike anything presented by the Carabidæ, which assists them in their motion through the water.


HALIPLUS FULVUS.


LACCOPHILUS VARIEGATUS.

The true Dyticidæ form three sub-families, the family type reaching its highest degree of development in the genus Cybister, in which the enormously expanded hind haunches are soldered to a metasternum of voluminous dimensions. They are found chiefly in tropical and sub-tropical countries. The genus *Dyticus*, consisting of insects nearly as large as those of the genus just mentioned, inhabit chiefly temperate, and even high, northern latitudes. Six species are found in Britain, Dyticus marginalis being one of our commonest pond insects, and the favourite tenant of many a juvenile aquarium. Laccophilus, a genus of smaller species, two of which are common in every English pond, have remarkably well-developed hind legs, and are excellent swimmers. The genus is widely distributed in all climates; the same is the case with *Hydroporus*, of which no fewer than fifty species have been found in Great Britain; but *Suphis*, and other allied genera, are confined to the tropics.

FAMILY GYRINIDÆ, AND THE ANOMALOUS FAMILY PAUSSIDÆ.

The *Gyrinidæ*, or "Whirligig Beetles," of the surface of our ponds and rivers, form the last family of Adephaga, and consist of a comparatively small number of genera and species, varying but little from a common type. They differ from the rest of the Adephaga in the absence, or where present, the slender, unjointed form of the external lobe of the maxilla, and in the possession of four eyes, the eye on each side being divided into two, one situated above for vision in the air, and the other below for espying what happens in the water. From the Dyticidæ, with which they agree in general form and habit, and in most parts of the structure of the mouth, they differ in their legs, the relative development of which is reversed, as it is here the anterior pair which are longest, whilst in Dyticidæ it is the hindmost. The two hinder pairs of legs are extremely short, broad, and compressed, modified, in fact, to suit their extraordinary mode of locomotion—a rapid skimming in curves or circles over the surface of the water. The rapid forward motion is produced by the quick fore-and-aft movement of these strong and well-knit members, and the curves by the long anterior legs, which, usually kept folded under the breast, are jerked out one at a time, so as to change the straight line of progression into a curve. When alarmed, they plunge into the depths of the liquid element, carrying with them a relatively large air-bubble to supply their needs until they return to the surface. The females lay their eggs on the leaves of aquatic plants, and the larvæ which emerge from them are remarkable for their general resemblance to small Centipedes, owing to the abdominal segments being furnished on each side with a slender conical process resembling legs, the terminal, or ninth segment, having four of these appendages, longer and more movable than the others. As these curious processes have been found—at least, the apical ones—to have a fine trachea, or air-tube, pasing through them to their apex, they are supposed to serve as breathing organs.


HYDROPHORUS GRISEO-STRIATUS.


SUPHIS CIMICOIDES.

Gyrinidæ are generally distributed over the earth, but, as already observed, the type is but little varied. The common British species (*Gyrinus natator*) is a fair representative of the whole family, the most remarkable species of which are the *Porrorhynchus marginatus* of Java, with its long and triangular upper lip, giving a snout-like appearance to the front of the head, and the *Enhydrus sulcatus* of Brazil, more than three-quarters of an inch in length. The *Gyrinus distinctus*

of our illustration is a continental European species, differing from our common Gyrinus by its more striated and less polished surface.

The family *Paussidæ*, which we have thought convenient to notice in this place, is one of those anomalous forms, numerous in the Coleoptera, whose position in any system is very uncertain. Some of their species are known to be tenants of the nests of Ants, and to be tended with care and jealousy by those insects; but nothing is known of the habits of the great majority, most of which are rare, and met with only in houses at night in tropical and warm countries, whither they are attracted by the lights burning in the rooms. If they are habitually guests of Ants, guarded and fed by them in the recesses of their nests, some of the anomalies in their structure might be accounted for, on the ground of the natural variations in the various parts of their structure not having been controlled by natural selection in the free struggle for existence. Granted this, it would be easy to believe they are strongly-modified forms of Carabidæ, allied to the sub-family *Ozæninæ,* as Burmeister believed them to be.

ENHYDRUS SULCATUS.

GYRINUS DISTINCTUS.

The *Paussidæ* are oblong insects of small size, distinguished at first sight from ordinary Beetles by the extraordinary form of their antennæ. These organs run into all sorts of fantastic shapes in the different species; but inordinate width and bulk, and the tendency to a bulbous form in the terminal joint, are the most general characters. The number of tarsal joints is normally five; when there are only four, it is in consequence of the small basal joint becoming inconspicuous or wanting; in other respects the legs, as well as the form and proportions of head, thorax, and body, are not essentially different from the same parts in many Adephaga. A peculiarity of the elytra—the existence of a small fold and breach of continuity in the lateral margin, near the apex—is very significant from the point of view of a relationship to the *Carabidæ,* as this curious feature is known to exist nowhere else in the Coleoptera than in the group *Ozæninæ* belonging to that family. Their faculty of crepitation also speaks for the same relationship, for the Ozæninæ, as well as the Artillery-beetles, possess this rare property. Against all this, however, stands the widely-different position of the mouth, and the structure of its different parts. The mouth, instead of being at the anterior extremity of the head, as in the Adephaga, is on the under side; but passing by this, as probably caused by the bulky antennæ necessitating the strengthening of the forehead, it must be allowed that the totally different form and nature of the mentum, or chin, goes quite against any near relationship to any of the Adephaga; for the definite form and structure, and the size of this organ, are quite essential characters of the tribe. In the Paussidæ it never approaches the Adephagous form, but is a narrow transverse plate, often indistinct, and the lower lip, which in Adephaga is subordinate to the mentum, is here of greater relative development. The maxillæ, too, are destitute of articulated outer lobe; but these members are so eccentric in shape in the family that not much reliance can be placed on this point.

More than one hundred species of these grotesque Beetles are known, chiefly from the tropical regions of Asia and Africa; but one (*Paussus favieri*) is found in South-western Europe. Some collectors in South Africa and in Australia have been able to secure a large number of some of the species by assiduous search in Ants' nests. With regard to their social relations to the Ants, less is known; but it appears that some kinds are really enforced guests of the Ants. Mr. Ayres, of Potchefstroom, declares this to be the case with regard to the *Pentaplatarthus paussoïdes.* He found a large nnmber of the insects by digging in the nests of an active species of *Formica* in the Transvaal, and observed the Ants dragging the Beetles into their galleries, further stating that they bring them out when the sun is shining, and pull them in again when clouds begin to appear. Other observers have noticed that the Paussi are not willingly guests of the Ants, but are forcibly seized and detained by them. A common Australian species is found under dried cow-dung; and Paussi are often found in South Africa under stones.

TRIBE PALPICORNIA.

The tribe Palpicornia have for their chief point of distinction among the Coleoptera the great length and slenderness of their palpi, which are longer and more conspicuous than the antennæ: these latter being short, of from six to nine joints only, the terminal ones thickened into a club. The maxillæ and their exterior lobes are unarmed. The typical genera of the tribe are aquatic, and have

hind legs adapted for swimming, like the Dyticidæ, from which the species are distinguished by their herbivorous habits, besides the fundamental differences in their antennæ and mouth organs.

The tribe consists of one family only (HYDROPHILIDÆ), containing five sub-families, of which four are water-insects, and the fifth, the Sphæridiinæ, live on the dung of land animals. The aquatic series comprises the fine genus HYDROPHILUS, which vies with Dyticus in the size of its species. *Hydrophilus piceus* is a well-known inhabitant of our ponds, and one of the largest of our British Beetles. It is of more convex form than any species of *Dyticus*, and distinguished from them also by its uniform deep black colour, and its less energetic motions in the water. Its mode of taking a supply of air is totally different from that of the Dyticidæ; for whilst the latter protrude the hind extremity of the body above the surface, the Hydrophilus elevates its head, and by a peculiar movement of the antennæ above the water, makes the air descend along the pubescent joints of the club, and thence to the fine hairs which clothe the flanks of the thorax, which pass it on to the stigmatic openings of the breathing tubes. There are some important differences, also, in the habits of the female insects with regard to the preservation of their offspring. The mother Hydrophilus weaves, by means of a tenacious fluid secreted by two spinnerets in the anus, a kind of cocoon, which she attaches to the under-surface of the leaf of some aquatic plant near the surface of the water, and which is provided with a tube rising above the surface, destined to introduce a supply of air to the interior. In this cocoon she lays her eggs, to the number of about fifty, enveloped with a cottony substance. The larvæ emerge from the bottom of the cocoon at the end of six weeks, and swim forth in search of food; and it is remarkable that, instead of being vegetable feeders like their parents, they are carnivorous, and of extreme voracity. They are somewhat similar to the larvæ of Dyticus, but much thicker and more fleshy, covered with leathery, finely-shagreened skin, and the mandibles are toothed. Like the Dyticidæ, they crawl out of water to undergo their transformation into the pupa, and thence into the adult Beetle, burying themselves for the purpose in the damp ground.


HYDROPHILUS PICEUS.

The keel-shaped ridge running down the middle of the sternum of this insect, on the under side

of the body, and ending in a sharp point, is developed at the end, in some tropical African species, into a very long and sharp stiletto, and serves, no doubt, as a defensive weapon. The allied genus (*Tropisternus*), of which there are many scores of smaller species in America, North and South, some of metallic colour and others striped with yellow, also possesses this armature. In *Hydrous caraboïdes*, a British species, next in size to *H. piceus*, the keel is very short, not passing beyond the haunches of the hind legs. Besides these two large species, a considerable number of smaller Hydrophilidæ are found in our ponds and streams, some, like the *Berosi* and the rare *Spercheus emarginatus*, wallowing in the soft mud at the bottom.

FAMILIES GEORYSSIDÆ, PARNIDÆ, AND HETEROCERIDÆ.

Some authors associate with the PALPICORNIA, or Phihydrida, the three families, GEORYSSIDÆ, PARNIDÆ, and HETEROCERIDÆ, induced to this course probably by considerations of convenience in reducing the number of detached families, rather than by any real similarity of organisation. The only constant points of agreement between these families and the Palpicornia are their aquatic mode of life and phytophagous habits. They vary much in the form of the antennæ, which are clavate only in some of the genera, and none of them have swimming feet; but in all the maxillæ and their lobes are, as in the Palpicornia, unarmed. As the only alternative is to treat them as so many separate tribes, we may introduce the little we have to say of them in this place.

The GEORYSSIDÆ are small insects of short, convex, and solid build, inhabiting damp places near water. Only seventeen species are known, chiefly from north temperate regions, but one or two have been of late years detected in Australia and Ceylon. Their antennæ have nine joints, the three last forming a club; the chin (mentum) is large and horny; the elytra are entire; the anterior haunches are cylindro-conic and exserted, and the posterior transversal; and the abdomen is composed of five segments only. The habits and early stages are unknown. One species (*Georyssus pygmæus*) inhabits the British Islands.

The PARNIDÆ are little Beetles of oblong, sometimes nearly cylindrical, form, and of strictly aquatic habits. The principal species are clothed with a dense silky pile, which, on account of its hydrofugal properties, has the important functional effect of aiding in the respiration of the insects, by attaching to the body, at the moment of immersion, a globule of air sufficient for their needs during long periods of submergence in the water. Thus, with more facility than a diver in his diving-bell, the Parnus can move about the depths of the pool, carrying the needful supply with him in his wanderings. According to Erichson, the globule is surrounded by a thin film of oily or viscous matter, secreted by the hairs with which the body of the insect is clothed. The antennæ of the Parnidæ are variable in form in the different genera: in the sub-family Psepheninæ being saw-shaped; in the typical Parninæ clavate, sometimes lodged in repose for protection in a groove under the eyes, and bearing a branch-like process from their second joint; and finally, in the Elminæ filiform and simple. The mouth organs are feebly developed. The legs are slender, and the last joint of their feet is much elongated, with highly-developed claws. The latter peculiarity is of great importance in the economy of the species, most of which inhabit swiftly-running waters, and require grappling instruments, such as are afforded by these strong feet and long claws, to prevent their being swept from the roots and stems of aquatic plants, or from the mossy stones amid which they find their food. The longest feet and claws are seen in the sub-family Elminæ, these members reaching a truly remarkable degree of development in *Macronychus quadrituberculatus*, a rare and local British species, found in the river Trent.

The HETEROCERIDÆ, like the GEORYSSIDÆ, consist of one genus only. The family contains, however, upwards of seventy species, distributed over nearly the whole globe. They are not strictly aquatic, preferring damp, sandy, or marly soil, on the margins of pools and ditches. They differ from the Parnidæ farther in the larger development of the parts of the mouth, and in the feet, which are adapted for burrowing, being short and strong, with the shanks of the two anterior pair widened, and furnished on their outer edge with a row of spines. The insects, in fact, have the habit of burying themselves in the loose earth, in which labour their fossorial legs are aided by the robust head and the great mobility of the prothorax.

TRIBE BRACHELYTRA.—FAMILY STAPHYLINIDÆ.

This numerous tribe, of which our common British insect, the *Ocypus olens*, or Devil's Coach-horse, is a typical example, is distinguished by the much abbreviated elytra, these organs, in all but a few genera, being so reduced in length that they leave nearly the whole of the upper surface of the abdomen exposed. They are, however, always of oblong or square form, with straight hind margins, and meet in a straight suture. The membranous wings, of normal length, and adapted for active flight, are closely folded beneath. In correspondence with the abbreviation of the wing-covers, the upper sides of the abdominal segments are of horny texture, like the under; the segments, further, are all mobile, and the abdomen is thus capable of flexure in all directions. The habit of curving the tail upwards is very characteristic of these insects, the tip of the body being used for pushing back the membranous wings, after flight, under the elytra; and in some small species it is carried habitually in a curled-up position, even in running. Many Brachelytra are of active predaceous habits, like Carabidæ; and in some of the genera, in which the elytra are much longer than in the majority, the resemblance to Carabidæ of the Truncatipennæ group is very great: but in these, as in the rest of the tribe, the totally different form of the chief parts of the mouth shows that we have to deal with a different type. The maxillæ differ from the same organs in the Adephaga in the outer lobe being never palpiform, though sometimes two-jointed, and the labium in being fully exserted beyond the upper edge of the mentum, the latter of which plays a subordinate part—the reverse, in fact, of what we see in the Adephagous tribe. This tendency towards a full development of the elements of the labium may be noted as an approximation to the mouth structure of the order Orthoptera, and as indicating a low position in the scale of specialisation of the Coleopterous tribes.

OCYPUS OLENS (DEVIL'S COACH-HORSE) AND LARVA.

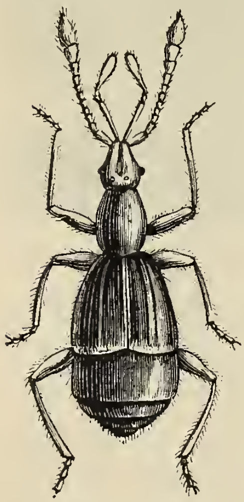
Many of the genera depart from the rule among the Pentamera section with regard to the number of tarsal joints. In some the four anterior feet have only four joints each; in many others four joints is the number to all the feet; and, again, some aberrant genera have only three joints. These exceptional cases, however, do not show any resemblance in the rest of their structure to the sections Tetramera and Trimera, to which they would be referred if the number of the tarsal joints were the sole character relied on. The antennæ are variable in form and in number of joints (nine to eleven); in extreme cases they are club-shaped. The sternal structure in the majority is remarkable for the atrophy or disappearance of the breastplates of the first segment, and partly of the second. In the insects thus

loosely knit the prothorax has extraordinary freedom of motion, to the extent of being capable of turning independently of the trunk; the sternum, however, presents more completeness and solidity in other of the sub-families, and in the Proteininæ resembles that of the family Nitidulidæ, in which the coxæ of the first and third hind pair of legs rest in transversal sockets.

The principal recent authors limit the tribe Brachelytra to the single family Staphylinidæ. The family is subdivided into eleven sub-families, and the number of known species at the present time does not fall far short of 5,000. They frequent the same haunts as the Carabidæ, and are distributed equally with them over all parts of the earth; they are, however, more varied in their habits. A large number of species are the guests of Ants, and are found only by assiduous search in the underground chambers of those insects. As many as 350 specimens, comprising seventeen species, chiefly of small Staphylinidæ, have been found by sifting the detritus of one nest of the Red Ant. Many of them are possibly only tolerated visitors of the Ants, resorting to the nests only in search of food. Multitudes of species live in the dung of animals, and in decaying animal and vegetable matter of all descriptions, some genera, of curious flattened form, being restricted to the confined spaces under slightly loosened bark of trees, and others to fungi and boleti. Their chief prey in these situations consists of other insects. They shun the daylight, and in the height of summer are scarcely ever seen abroad; but in early spring, and in warm evenings after sunset, they fly abroad in great numbers, seeking fresh hunting-grounds, and thus disseminating their species over wide areas. The larvæ resemble the perfect insects more than is the case in any other family of Coleoptera, affording another indication of the low rank of the Brachelytra in the order.

FAMILIES PSELAPHIDÆ AND SCYDMÆNIDÆ.

The PSELAPHIDÆ are a group of very small Beetles of anomalous structure, which bear a certain analogy to the Paussidæ, being, like them, of recondite habits, and—at least, in some well-established cases—the enforced guests of Ants. In both families the antennæ display great vagaries of form, and the parts of the mouth exhibit singular variations from the forms ruling in the allied groups. If, however, the hypothesis of anomalous modification be accepted, the Pselaphidæ must be admitted to be modifications of a different type from that which the Paussidæ were derived from; and just as the latter are possibly offshoots of the Carabidæ, the present family may be similarly related to the Staphylinidæ. Some authors, indeed, class them as a family of the Brachelytra. They have similarly abbreviated wing-covers and horny dorsal segments of the abdomen, but here the similarity ceases; the mouth-parts differ in the soft membranous texture of the lower jaws and their external lobes; their abdomen (generally of five segments only) has little flexibility, and the tarsi consist only of three joints. The antennæ vary in the number of their joints from the normal number of eleven to six, two, and even a single joint, and are often thickened into a club of various forms. Sometimes they are short and rigid; at other times very long and bent into an angle, or elbowed.



PSELAPHUS HEISII.

The Pselaphidæ are distributed through all climates, being found in the tropics as well as in temperate and high northern latitudes. Many of the more extraordinary forms occur in Australia. We give a figure of one of our English species (*Pselaphus Heisii*) which represents the ordinary shape of the family, and which, like most of the typical species, is found by searching at the roots of herbage on sandy banks, especially near water. The Ant-nest kinds are those which exhibit the strangest aberrations in the number and form of the antennal joints, such as the genus Claviger, in which these organs have only six joints, and all the parts of the mouth exhibit equally curious degradations of structure. These insects are totally blind, external eyes and optic nerves having alike disappeared, and they seem to be helplessly dependent on the Ants for sustenance. A well-known British species (*Claviger testaceus*) is the guest of the Common Yellow Ant (*Formica flava*), passing its whole life in its nests, and being fed from the mouth of the Ants, and jealously guarded, with the object, as it has been stated, of securing a steady supply of a grateful liquid, secreted by the Clavigers from certain curious

pencils of hairs on the wing-covers, and from a cavity on the dorsal surface of the abdomen. According to a recent observation of Lespès, herds of these diminutive milch-cows, belonging to an allied species (*Claviger Duvalii*) appear to be the hereditary property of certain families of Ants, who know their utility, other families of the same species, who have had no experience of such pets, refusing to tolerate them; he having found that Clavigers, when taken from one nest and put into another in a different locality, were immediately destroyed. The species of the allied genus *Articerus*, found in Australia, have been observed by Mr. Bostock, of Fremantle, to be also the jealously-guarded pets of Ants. One genus of Pselaphidæ is found in caverns in the South of Europe, some of its species being blind, and others furnished with excessively minute eyes.

The family Scydmænidæ differ from the Pselaphidæ by their fully-developed elytra, which cover the abdomen to its apex. But they differ very essentially also in other respects, especially in their five-jointed tarsi and their abdomen of six segments. In general form and colour they closely resemble Pselaphidæ, and are met with in the same situations.

TRIBE NECROPHAGA, OR CLAVICORNIA.

Under the head of Necrophaga some modern entomologists include a large number of families which have scarcely any characters in common, except that of feeding on decaying animal or vegetable substances. As, however, they vary amongst each other in structure not much more than the Brachelytra—admitted to be a natural group—their association under one tribe is not without plausible grounds. The antennæ have a general tendency to assume a clavate form, that is, the terminal joints are more or less thickened, the three last sometimes forming a perfoliate club; but to this there are some exceptions, and in extreme cases the antennæ are long and simple. There are also, as in the Brachelytra, numerous exceptions to the rule of five-jointed tarsi and the loosely-knitted body. We observe, in fact, here, as in that tribe, all degrees of consolidation, commencing with species in which the abdominal segments—head, and thorax, and limbs—have all free movement, and ending with others in which the parts are more or less consolidated or locked together. We commence our review of the families with those which have the nearest relationship to the Brachelytra.

FAMILY SILPHIDÆ, OR CARRION-BEETLES.

The Silphidæ comprise, besides many genera of small and obscure insects, the conspicuous and gaily-coloured Necrophori, or Burying-beetles. In all, the abdomen has six free segments, and the antennæ are distinctly thickened or clavate at the tip. The insects which give their name to the family are further distinguished by their considerable, and sometimes large, size, their ovate or oblong, slightly-flattened form, and their rather long spiny legs. In the genus Necrophorus the elytra are shortened and truncated at the tip, leaving the end of the abdomen exposed. The family comprises also a group of Cave-beetles of strange form (Leptoderinæ), one genus of which (Leptodirus) has an excessively long and cylindrical prothorax, joined to a short, oviform hind body, destitute of membranous wings. The species are blind, and are found only in the most retired parts of caves in Carniola, hidden in fissures of stalagmites, or clinging to stalactites on the walls. They walk slowly, with body raised on their long legs, and when a sound is heard, suddenly lower themselves flat to the ground, with legs stretched out and antennæ elevated. Other genera, equally blind, and of the same pallid colour which distinguishes cave insects, present all gradations of form, between the eccentric Leptodiri and the ordinary-looking genus Catops, of which many species are quite commonly met with in England, in dried carcases or skins of animals in parks and similar situations.

Four or five species of Necrophori, or Burying-beetles, are not uncommon in England; one (*N. vespillo*), the handsomest, with its broad bands of bright orange and rows of yellow hairs, being frequently seen in streets and gardens in the fine days of spring, probably resting on its long journeys through the air in search of fresh booty. If we would see them in greater number, and at work, we have only to place upon light soil in a field, in some suitable situation known to be favourable to insects generally, a dead mouse, or similar small animal, and examine it a day or two afterwards. If the weather be fine, a number of Necrophori, sometimes of two or three distinct species, may then probably be caught in the act of burying the dead body. If we luckily time our visit at the commencement of the operation, we shall see them flying one by one from a distance, and settling near the edge of the carcase. They proceed by excavating the soil around and underneath until, in a few hours, by

the force of gravity, or by dint of various tugs by the Beetles themselves, the body is lowered, in some cases to the depth of a foot, and the loose soil closes over it. The mother Beetles then lay their eggs in the carcase, which are soon hatched, the larvæ being elongated fleshy grubs, widest in the middle, with three pairs of weak legs, and supplementary locomotive organs in the shape of a row of stiff spines on the dorsal surface of the body, proceeding from the hind edge of a horny plate, with which each segment is furnished. These spines, which are supposed to assist the larvæ in wriggling through the substances on which they feed, are more than an inch long when the insects are full grown. They then leave the carcase to undergo their transformations, burying themselves in the soil, and elaborating a kind of cell, with smooth inner walls, in which to change into the pupa stage. In about fifteen days they emerge as perfect insects, and fly abroad. The carcases buried by the Necrophori are usually devoured to the last morsel, the number of Beetles which apply themselves to this work being proportioned to the size of the dead body.


NECROPHILUS VESPILLO (THE BURYING-BEETLE).

Other genera of the family do not possess the burying instinct; the closely-allied *Necrodes littoralis*, which is also a common British insect, feeding and breeding in the interior of the carcases of large dead animals. Many of the true Silphæ, oval insects, with smaller heads, and wing-cases generally covering the end of the abdomen, prey on Snails, chiefly Helices, living as well as dead; and others on dead fish or reptiles, or the skins of dead animals; some live in trees, and feed on Caterpillars. The larvæ of these have similar habits to the perfect insect, and, unlike their near relatives, the Necrophori, who are born in the midst of an ample supply of food, they search independently for their prey; their legs, therefore, are strong and well developed. The genera Necrophorus and Silpha, consisting of about one hundred and twenty species, are confined, with very few exceptions, to the north temperate zone. Their absence or extreme rarity in the tropics and warm temperate latitudes may partly be accounted for, perhaps, by their functions as scavengers being there performed by the ubiquitous Vultures.

FAMILIES TRICHOPTERYGIDÆ, SCAPHIDIIDÆ, PHALACRIDÆ, AND NITIDULIDÆ.

The TRICHOPTERYGIDÆ are a family of exceedingly minute species, many being less than one-fiftieth of an inch in length, the smallest of all known Beetles. They are found among decaying vegetable matter, the litter of old haystacks, under manure-heaps, and so forth. Their movements are lively, and those which possess wings fly well. The patience and industry of modern entomologists have been rewarded by the discovery of about one hundred and fifty species of these almost microscopic creatures, which have been subjected to careful examination, even in many cases to the dissection of the parts of their mouths, and they have been classified under ten well-characterised genera. The British

species and those of the Atlantic islands have been satisfactorily investigated by the Rev. A. Matthews; but the group is by no means confined to temperate climates, several species having been found in India and Ceylon. In general form the Trichopterygidæ are oblong or oval, sometimes slightly flattened, sometimes convex; generally finely pubescent, but often polished. Their antennæ are eleven-jointed, the three terminal joints forming a club, and their tarsi are three-jointed. The parts of the mouth present nothing remarkable, except the great development of the stem of the lower jaws, which is long and thick, and bears at its extremity the usual two lobes (or the blade and its outer lobe), both armed with fine teeth, the blade with one, the lobe with several. The wing-covers are sometimes much abbreviated, and sometimes entire, but the membranous wings beneath them are of extraordinary shape, and furnish the chief character as well as the name of the family. They resemble a miniature feather, having a slender horny stem supporting a lance-shaped membranous blade fringed with long hairs, which latter project when the wings are folded beneath the wing-cases. In some species the wings are rudimentary, and in others they disappear almost altogether. These latter are blind insects.

The SCAPHIDIIDÆ are Beetles of larger size, from one-tenth to a third of an inch in length, and recognisable by their short, thick, boat-shaped form, much narrowed both in front and behind, with glossy black or chestnut-coloured surface. Their antennæ and legs are rather long and slender, the former with their five terminal joints generally thickened. Their lower jaws are weak and membranous, their wing-covers clipped short behind, leaving the conical tip of the abdomen, of which the four apical segments are horny above, exposed. The tarsi are formed of five slender joints. These Beetles are very nimble on their legs, and fly well. They live and breed in fungi, and are sparingly distributed over the whole earth, under the Equator as well as beyond the Arctic Circle in Lapland. Some of the species are prettily spotted.

The PHALACRIDÆ are a group of small Beetles of short and convex form of body, having eleven-jointed antennæ, of which the three terminal joints are thickened into a very distinct club. The wing-cases are entire, covering the whole abdomen, and the abdomen is composed of five freely-articulated segments. The tarsi are five-jointed, the three first having fine brush-like palms, and the fourth being very short. Most of the few known species are found on flowers, and they fly well.

The NITIDULIDÆ are a very numerous family, distinguishable by the short, oblong, generally depressed form, with truncated wing-cases and antennæ terminated by a button-shaped club. The maxillæ, or lower jaws, are remarkable for the absence of the usual exterior lobe. The tarsi are five-jointed, with the fourth very small, and the abdomen consists of five free segments. The head is almost always retracted, and protected by the projecting lateral angles of the thorax. Eight hundred species are known, distributed over all climates, from the Equator to the Arctic Circle and the islands in the Antarctic Sea. In habits they offer great diversity; for although the majority exhibit the necrophagous tendencies of the tribe, feeding and breeding in decaying vegetable and animal substances, such as fungi, rotten bark and wood, in the exudations of trees, and in the dried skins and carcases of animals, a great number are found only on flowers. In tropical America certain species of one of the genera (*Carpophilus*) are seen in countless multitudes in the flowers of palm-trees; and in Europe the little brassy Nitidulids of the genus Meligethes—true Flower-beetles—sometimes prove very destructive to cultivated plants, on account of their numbers. *Meligethes æneus* is one of the chief enemies of farmers in some parts of Germany for the injury it does to rape crops. These ubiquitous Beetles in many species are among the commonest insects of our fields in the summer, it being rare to find a wild flower untenanted by one or more individuals.

FAMILIES TROGOSITIDÆ, COLYDIIDÆ, RHYSODIDÆ, CUCUJIDÆ, CRYPTOPHAGIDÆ, LATHRIDIIDÆ, MYCETOPHAGIDÆ, THORICTIDÆ, DERMESTIDÆ, BYRRHIDÆ, HISTERIDÆ.

We now come to a series of families, all that remain to be noticed of the tribe Necrophaga, which not only differ very materially in their characters from one another, but depart, each in its own way, from the chief features of the tribe.

The first (TROGOSITIDÆ) are closely allied to the Nitidulidæ in some parts of their structure, but they differ in important characters, the form of the lower jaws, and the tarsi, being peculiar, as in the Nitidulidæ, but in the reverse way: thus the lower jaws have only one lobe, but it is

the blade, and not the outer lobe, which is subject to disappear; and in the tarsi it is the first joint, and not the fourth, which is reduced in size. In their general form and habits also the two families are very different. The Trogositidæ are of much larger average size, longer and narrower in form (except in a few aberrant genera), and often of rich metallic colours. They are essentially wood-feeders, and are never found on flowers or in animal substances. Some few species, *e.g.*, *Trogosita mauritanica*, have acquired a preference for wheaten flour and other kinds of cereal meal, and multiply at times in meal-bins, so as to prove a great pest to the miller and the baker. The family is generally distributed over the earth. About one hundred and fifty species have been described.

The Colydiidæ are a group of very small Beetles, living under bark or in rotten wood or fungi, of oblong and flattened or long and slender form, distinguished from the preceding family, *inter alia*, by their four-jointed tarsi. The abdomen, which in the preceding families of Necrophaga has all its segments free, here shows a more consolidated structure, only the last, or the last two segments being separately movable, a character which indicates a tendency towards a higher type than either of the two tribes Necrophaga and Brachelytra. The maxillæ have two lobes, and the antennæ are more or less clubbed at the extremity.

The Rhysodidæ are small wood-eating Beetles, of similar form to the more elongated genera of the preceding family. They are distinguished at first sight by the deep furrows which score the upper surface of their body in a longitudinal direction. Their antennæ are not clavate, but formed of rounded joints of nearly equal width, and eleven in number. About a dozen species only are known.

The Cucujidæ are also wood-eaters, but more exclusively restricted to the bark of trees than the members of the preceding families. Their general form is oblong, and their colours pale or brown. Nearly all the numerous species are, in correspondence with this confined habitat, more or less flattened, some of them so much so that their bodies are scarcely thicker vertically than a sheet of ordinary writing-paper. The antennæ are long, often slender, eleven-jointed, with joints more or less rounded in form, the three last thickened into a club. The abdomen has six nearly equal segments, all free. The tarsi are normally five-jointed, but the hind pair in the males of many species have only four joints, and in many others the first or the fourth joint is much reduced in size. The mandibles are always well developed, and in some species are large and exserted. There are few exceptions in this family to the prevailing sub-cortical mode of life. One of these is furnished by the genus *Silvanus*, which infests sugar-casks and meal-bins. The species are sometimes found alive on the windows of our houses, or floating dead in our teacups. The flattened species are excessively numerous and varied in tropical America, living gregariously under the bark of recently-felled trees, so closely fitting that the blade of a penknife is with difficulty forced underneath.

The Cryptophagidæ differ in general appearance from Cucujidæ by their more oblong or elliptical form and pubescent surface. Nearly all are Beetles of very small size, inhabiting decayed wood, vegetable detritus, boleti, Ants' nests, and so forth. The antennæ are eleven-jointed, and have a distinct three-jointed club; the elytra are entire, covering the whole abdomen, which has five free joints; and the tarsi, with some exceptions in the males, are five-jointed. Most of the 300 species hitherto described are European, but many are found in Siberia and North America, and a few are known from warmer climates. The species of one genus (Telmatophilus) are found on aquatic plants; others of very diminutive size, belonging to the genus Ephistemus, attack mouldy paper, and are sometimes seen in old books in neglected libraries.

The Lathridiidæ consist, like the preceding, of very small oblong or linear Beetles, of pale brownish colours, having antennæ of eleven joints, with a club formed sometimes only of one, at other times of two, and again of the ordinary number of three joints. The tarsi consist only of three simple joints. Their habits are very similar to those of the Cryptophagidæ. More than 350 species are known, of which a large number inhabit the British Islands.

The Mycetophagidæ differ from the six preceding families in their oblong or oblong-ovate, convex form of body, fine pubescent clothing, and the ornamentation of their wing-covers with reddish belts or spots. Their antennæ are clubbed, and their abdomen consists of five movable, nearly equal segments. The tarsi have only four distinct joints, reduced to three in the anterior feet of the males. They live in boleti and fungi, or under the bark of dead trees.

The Thorictidæ are a small group of minute, broad, and convex Beetles, remarkable for the great

relative size of the prothorax. Their antennæ are clubbed and eleven-jointed; their tarsi five-jointed. The first and last ventral segments of the abdomen are longer than the three intermediate ones. The species, only twenty in number, are peculiar to the countries bordering the Mediterranean.

The DERMESTIDÆ are a group of Beetles only too familiar to us by the destruction several of the species cause in our museums, or warehouses where animal substances are stored. They are oval or oblong insects, of small size, recognisable by their dense clothing of fine-laid hairs or scales, short clubbed antennæ, linear five-jointed tarsi, and the grey spots or belts with which their wing-cases are generally variegated. The larger species, belonging to the typical genus *Dermestes*, are the most voracious of all, living both in their larva and adult states in skins or bones of animals, furs, leather, salted meats, and so forth, and multiplying sometimes to a prodigious extent where these are long kept undisturbed. In consequence of these habits, and the frequency with which these objects are transported by ships in the way of commerce between one distant country or another, some of the species — as, for example, the *Dermestes lardarius* and *vulpinus* of our illustration—are very widely distributed. The pests of museums are of much smaller size, and belong to the genus Anthrenus, one of them, a notorious depredator, having the significant name of *Anthrenus musæorum*. The larvæ of these insects are distinguished from those of all other Coleoptera by their clothing of long, erect hairs. Those of the above-named species of Dermestes are of more elongated form than the others, and taper towards the tail, which is armed above with two horny hooks; the long hairs are erect, except behind, where they are more rigid and directed backwards. The larvæ of the *Anthreni*, on the other hand, may be known by their more oval shape, the absence of hooks on the apical segment of the body, and the presence of numerous pencils of hairs on the sides of this and several preceding segments, which are susceptible of being raised at the will of the insect, and spread out in the form of a fan, which is at times set in active vibration. These larvæ feed on the dried fleshy parts of the substances they attack, concealing themselves from observation in the interior, where they pass through the pupa stage, and emerge by gnawing a hole when they attain their full growth as winged Beetles. It must be remarked, however, that the whole of the family do not partake of these exclusively necrophagous habits. Many resort to flowers in their adult stage, although bred in dried animal substances, and some are found in the larva state in rotten wood. The larvæ of *Anthreni* and *Attageni* have been found in winter in Swallows' nests, and those of another Dermestid (*Tiresias serra*) have been seen devouring the eggs of a Moth (*Liparis dispar*).

DERMESTES LARDARIUS AND D. VULPINUS.

The BYRRHIDÆ comprise the curious olive-brown or greenish insects, of compact oval or round form, known familiarly as Pill-beetles. The head and legs in repose, or when the insect is alarmed, are retracted, the former within the prothorax, and the latter in depressions on the under surface of the body, the shanks being received within a groove of the thighs, and the feet within a similar groove of the shanks. The body is clothed with a very dense and short velvety pile, and some species are tinted with metallic colours between the velvety patches. They differ esentially from the Dermestidæ in the greater consolidation of the framework of the body; for whilst the latter have all the five segments of the abdomen freely articulated, the three basal segments in the Byrrhidæ are soldered together. The more typical genera are peculiar to the northern temperate zone, the species being more numerous in Alpine situations, preferring light, sandy soils, where they appear to subsist on the roots of herbage

or on moss. In tropical America a genus named *Chelonarium* is found differing from the rest of the family by their filiform antennæ, concealed in repose in grooves along the breast. These are much less convex than the *Byrrhi*, and have a naked shining surface. They live on trees.

The last family of Necrophaga—the HISTERIDÆ—are recognisable at once from all their relatives by their general appearance, or facies, although this is subject to wide modifications. The majority are of compact oblong or nearly cubical shape, with solid glossy integuments of deep black or brassy colours, scored above with a few sharp striæ, the head being retractile within the prothorax, and the gait much resembling that of a Tortoise. The general air of relationship is retained, although some of the genera are modified into oblong and flattened forms with exserted heads, and others are changed in an opposite direction into tiny cylinders—modifications corresponding with the changed mode of life of the species, the ordinary cubical Histeridæ living on dead animal and excrementitious substances, and in loose decaying vegetable matters. The oblong and flattened species are restricted to narrow crannies under bark, where they live in company with the equally flattened Cucujidæ, and the small cylindrical kinds bore into the trunks of trees. The last-named, belonging chiefly to the genus *Trypanæus*, when seen at work at a dead tree, resemble little animated gimlets. They are furnished with sharp triangular heads, which are plunged into little holes in the wood, made by the jaws in places where the bark has been stripped off, and twirling their bodies the insects rapidly drill their way into the interior, a stream of fine sawdust meanwhile trickling from the holes. Some of the very large species with projecting mandibles feed on inspissated sap exuding from the crowns and stems of fallen palm-trees. As to the structural characters of the family, the chief distinctive features are the abbreviated and truncated wing-covers, and the short, retractile, elbowed and clubbed antennæ. Histeridæ are found in all climates, and are exceedingly numerous in generic and specific forms. About 1,200 species have been described.

CHAPTER IV.

THE LAMELLICORN AND SERRICORN BEETLES.

PENTAMERA (*continued*)—TRIBE LAMELLICORNIA—High Degree of Specialisation of the Tribe—Concentration of the Nervous System—Larvæ and Metamorphosis—Horned Species—FAMILY LUCANIDÆ, or STAG BEETLES—FAMILY SCARABÆIDÆ, or TRUE LAMELLICORNIA—Dung-feeding Scarabæidæ—The Sacred Beetle—Pill-rolling—A Parasitic Species—Burrows of Geotrupes—Leaf-eating Scarabæidæ—Cockchafers — Goldsmith Beetles—Rhinoceros and Elephant Beetles—Rose-chafers — Goliath Beetles — TRIBE SERRICORNIA — Peculiar Structure of the Fore and Middle Sternums — FAMILY BUPRESTIDÆ—FAMILY ELATERIDÆ, or CLICK BEETLES—Fireflies—TRIBE MALACODERMATA—Glowworms—Object and Cause of their Light—FAMILIES CLERIDÆ, PTINIDÆ, AND BOSTRICHIDÆ.

TRIBE LAMELLICORNIA.

THIS tribe comprehends all those conspicuous members of the Beetle order known by the names of Scarabæi, Cockchafers, May-bugs, Rosechafers, and so forth, which, by their large size, their great numbers, the singular habits and striking form of many of the species, and the great destruction many of them cause to trees and farm produce, have in all ages attracted popular attention. They are recognisable by the short antennæ being terminated by a lamellated club, formed by the three or more apical joints being elongated (on one side only), each into a little plate or "lamella," which are separately movable in the chief group, or Lamellicornia proper, and immovable in the Lucanidæ, or Stag-beetles. The parts of the mouth show a high degree of specialisation, in the great development of the solid horny mentum, or chin, and the subordination of the labial or lingual parts, which are more or less hidden within the mouth, behind the front edge of the chin. These characters, taken in conjunction with the consolidation of the abdominal segments, of which, in some genera, the connecting sutures of the ventral side are even obliterated, and a corresponding concentration of the nervous system, shown by the union—at least, in the highly-developed sub-families—of the ganglions of the hind body into a single large mass within the thorax, justify the views of those entomologists who have held that this tribe are the most highly organised of all Coleoptera. The legs in all the species are more or less long, and furnished with spines and transverse ridges, the shanks of the fore pair having one or more strong tooth-like projections on their outer edge, indicating fossorial or burrowing habits. The tarsi are always five-jointed.

There is more uniformity in the form of the larvæ and the nature of the metamorphosis in the Lamellicorns than in almost any other tribe of Coleoptera. A Lamellicorn larva may be known by its fleshy cylindrical form, curved inwardly towards the hind extremity. The curvature appears not to be under the will of the insect, except, perhaps, in its very earliest stage, and consequently the obese grub habitually rests on its side. Its skin is of fine, semi-transparent texture. Its head is rounded and horny, and furnished with strong mandibles, but destitute (with rare exceptions) of eyes. The thoracic segments bear three pairs of horny feet, and the ninth or terminal segment of the abdomen is greatly enlarged, and generally divided into two parts by a transverse furrow, simulating a division into two segments. The food of these larvæ varies according to the different sub-families, those belonging to the Coprophagous divisions living, like the adult insects, on the dung of animals, and the others generally on vegetable substances, living or decayed. The former pass through their various stages of growth rapidly, but the larvæ of the vegetable-feeding species are slow in reaching the pupa state. The slow-growing species, especially the Cockchafers, the life-history of many of which has been well investigated, take from two to three years. The mode of passing the pupa period of their lives is similar in all. The grub, namely, on completing its growth, forms in the soil an oval chamber, in which it undergoes the change. There are some exceptions to this rule, the most remarkable of which are certain cases in which species are parasitic on other members of the tribe.

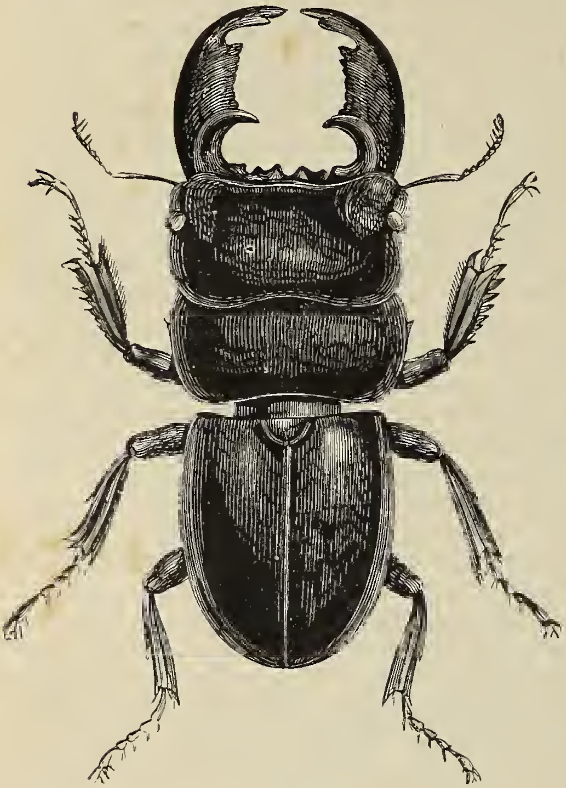
The Lamellicornia include some of the largest and handsomest Beetles known; the sub-family Cetoniinæ, or Rosechafers, uniting elegance of form and beauty of colour in a remarkable degree. The horns, with which their head and thorax are often armed, and which imitate in shape in different species those of the Rhinoceros, the Goat, the Stag, the Reindeer, and other large animals, and their general herbivorous habits, have induced some authors to consider them as the analogues of the Pachyderm and Ruminant orders among the Mammals. Notwithstanding their bulk, they are, as a rule, strong flyers. The Cockchafers are well known for their capabilities in this respect; as is also the Geotrupes, "the shard-borne Beetle, with his drowsy hum" of Shakspere. *Trichius fasciatus*, a handsome species, sometimes found abundantly in South Wales, flies about flowers with the activity of a Humble Bee, which it much resembles. Even the great Rhinoceros and Elephant-beetles of tropical America, weighted by their horny armature, fly long distances over rivers and lakes in sultry evenings. To sustain these efforts of prolonged flight, strong wing-muscles are necessary, and a well-developed respiratory apparatus; we find accordingly that the ordinary breathing tubes in these insects are not only greatly enlarged and ramified, but furnished throughout the body with supplementary air-vesicles, which act in the double capacity of lightening the specific gravity of the body and intensifying the aëration of the nutritive fluid, on which increased muscular volume and energy depend.

More than 7,000 species of this highly-endowed tribe have been already described, and numbers of new species are continually being discovered by travellers. They are divided into two families, very unequal in point of numbers, viz., the Lucanidæ, or Stag-beetles, and the true Lamellicornia, or Scarabæidæ.

FAMILY LUCANIDÆ.

This family is distinguished from the Scarabæidæ by the leaflets of the antennal club being fixed. This character is so constant that, added to the widely different general form of the insects, and the largely-developed projecting mandibles of the males of the majority of the species, it has induced many modern authors to consider the Lucanidæ as an independent group, totally distinct from the true Lamellicorns. If we look only at the extreme or more specialised forms of the two families, no other conclusion could well be arrived at; and it happens here, as in other large groups of Coleoptera, that the more specialised forms constitute the great majority of the genera and species of both families. On comparing, however, the less typical genera of the two, such as the *Æsalinæ* in the Lucanidæ, and some of the flat *Troginæ* in the Scarabæidæ, an approximation is observed between the two groups. If we trace the gradation of forms upward from this common point, we find, on the one hand, the Lucanidæ increasing in development of mandibles, with crown of head and thorax losing all traces of armature; while on the other hand, in the *Scarabæidæ*, the mandibles dwindle to useless, partly-membranous blades, and the horn-like processes on the head and thorax increase in size and variety of form.

About 550 species of Stag-beetles have been described. Being pre-eminently wood-feeders, and living in their larva stage in the interior of the trunks of large trees, they are found plentifully only in well-wooded countries; and in or near the tropics, where the forests are of varied kinds of trees, they present themselves in the greatest number and variety. We have in England only three species: Lucanus cervus, Dorcus parallelopipedus, and Sinodendron cylindricum. The last-named is found in all stages, sometimes in great plenty, in the interior of dead ash-trees. We figure a gigantic species of Dorcus found in Java. *Lamprima*, a remarkable genus of metallic-coloured Stag-beetles, with straight mandibles, is peculiar to Australia; but the most eccentric form of the family occurs in Chili: this is the *Chiasognathus Grantii*, which has excessively lengthened saw-like jaws, longer than the rest of the body.



DORCUS TITAN.

FAMILY SCARABÆIDÆ, OR TRUE LAMELLICORNIA.

The host of species belonging to this second and greater division of the Lamellicorns are grouped under eleven natural sub-families, which themselves fall into two groups, according to the position of the spiracles, or breathing-holes in the sides of the abdomen. Seven sub-families, forming a legion called *Laparostictica*, have the abdominal spiracles all situated in the connecting membrane between the dorsal and ventral arcs of the abdominal rings. They are further distinguished by the ligula, or tongue, being distinct from the mentum. Four sub-families, forming the legion *Pleurostictica*, have the spiracles partly in the connecting membrane and partly pierced in the ventral arcs of the segments; in these the ligula is nearly always soldered to the inner side of the mentum.

To the first legion belong the numerous sub-family of *Coprinæ*, which include the greater part of the dung-feeding Lamellicorns, and are distinguished by the front part of the head, or *clypeus*, being extended as a semicircular shield over the mouth, and the general absence of a scutellum. Many of them are fine insects, often of rich metallic colours, and remarkable for the horns and eccentric protuberances with which the head and thorax of the males are adorned. Such are the *Phanæi* of the warmer parts of America, and the *Onthophagi*, spread over all tropical and temperate countries; of the latter about 500 species are known, and the horns of the male insects are more varied in shape than in any other group. In one section of the sub-family the hind legs are elongated, and the tarsal joints short and of equal width; to this the sacred Scarabæi of the ancient Egyptians belong. These Beetles have the singular habit of forming pellets of dung, by rolling portions of this substance along the sandy soil by means of their long hind legs. It has long been taken for granted that the object for which these remarkable insects roll these dung-pills with such astonishing industry and pertinacity is to provide food in this form for their unborn progeny. The account generally given in books on natural history is to the effect that the pellets are rolled chiefly by the female insects, which deposit an egg in each, and trundle the precious burden, walking backwards, to a burrow previously excavated in a dry bank at some little distance. Often more than one individual is observed working at a pellet, especially when this falls into some hole, whence additional aid is necessary to extract it. Sometimes pellets have been seen stolen from the lawful owner by a brother Scarabæus, under pretence of giving help, and cases have been circumstantially related in which the males encourage and help their mates. The essential point in this curious

C

A

B

CERAMBYX HEROS, MALE (A); AND LUCANUS CERVUS (THE STAG-BEETLE), MALE (B) AND FEMALE (C).

history—the laying of an egg in the pellet—has, however, been called in question by a most accurate observer, M. Fabre, who declares, as the result of numerous and long-continued observations, that there are no eggs in the pellets. He has further shown that the dung is gathered and rolled and deposited in burrows solely in order to furnish a gluttonous feast to the Beetles themselves. The eggs, he believes, are deposited in a different way, in the midst of a supply of more succulent parts of the excrement. As to the stealing of pellets one from the other, M. Fabre confirms the statement, and gives a most amusing description of the different ways in which the robbery is effected.

In the typical genus *Scarabæus*, or *Ateuchus*, the semicircular clypeus is divided by sharp notches into a series of triangular teeth, and in repose the tooth-like projections of the anterior shanks flank the fore part of the body, owing to the fore legs being retracted. It is supposed to be either the resemblance to sun-rays thus produced, or the singular instincts of the insects, or both, that led to these Beetles being regarded as sacred by the Egyptians. The commonest species in Lower Egypt (*Scarabæus sacer*) is considered to be that most frequently represented on Egyptian monuments. This is a smooth black species ; but a brilliant golden - green kind, named *S. Egyptiorum*, found on the Upper Nile, the primitive home of the strange race who gradually spread over the lower valley, was believed by Latreille to have been the species originally worshipped.

SCARABÆUS SACER (SACRED BEETLE).

About seventy species of Scarabæus are known. They are confined to the Old World, having their metropolis in tropical Africa, where several species of great size and rich colours are met with. None are found in the north temperate zone. *S. sacer* occurs in all the littoral countries of the Mediterranean. In America the Scarabæi are represented by the genus *Canthon*, in Australia by *Cephalodesmius* and others, and in Madagascar by the brilliant *Epilissi* —all much smaller insects, but having similar habits.

The remaining Copridæ differ from the above by their much shorter hind legs, the tibiæ of which are more or less dilated at the tip, and by the weak tapering tarsi. In this group, owing to the digging and burrowing habits of the species, some of which excavate galleries two or three feet deep in clayey earth, beneath the droppings of large herbivorous animals, the tarsi become of very subordinate importance, and in one South American genus (*Dendropœmon*) three of the joints disappear altogether. The females in this group deposit their eggs in unformed masses of pabulum, either drawn into the underground galleries excavated by them, or simply left on the surface.

The sub-family *Aphodiinæ* have a projecting clypeus similar to that of the *Coprinæ*, but they differ from the latter by their stronger and often armed lower jaws. They are also more elongated insects, with less voluminous sternum, and are nearly always provided with a scutellum. The genus Aphodius is copiously represented in temperate and high northern latitudes, and contains few tropical

species. All are strictly coprophagous insects, exhibiting no special instincts, but breeding in the substance which constitutes their food as adult insects. A remarkable exception to this uniform habit has, however, been discovered by Dr. Algernon Chapman, in the British species *Aphodius porcus*, which he found to be parasitic on *Geotrupes stercorarius*. He states that at about the time the parent Geotrupes closes the underground chamber in which she has laid one of her eggs with a store of food for the larva when hatched, the female Aphodius forces a way into it, eats the egg, which in volume is larger than herself, and having thus removed the prospective owner of the store of pabulum, lays her own eggs in little cavities which she forms in the pabulum itself, thus appropriating the supply of food for her own future offspring, and at the same time securing a snug asylum, free from the perils of the above-ground abodes of her sister Aphodii.

The genus Geotrupes forms the type of another sub-family of the section Geotrupinæ, distinguished from the preceding by the small clypeus, which leaves the mandibles and other parts of the mouth exposed. In habits the species are similar to those members of the Coprinæ sub-family which provide for their offspring by excavating tunnels or galleries under the droppings of large quadrupeds, and laying their eggs in these secure retreats by the side of a store of provender. But from the observations of Dr. Chapman we learn that the parent Geotrupes show much engineering skill in the formation of these underground nesting-places. In watching *Geotrupes stercorarius*, he observed that both male and female busied themselves in the work of carrying down pabulum into the burrows. These latter consist first of a vertical shaft underneath a cow-dropping, and then of a subsidiary gallery carried along the surface of the ground from this point to the edge of the dropping, where the removed earth is ejected. In the walls of these a number of small horizontal cavities are hollowed out at varying heights, each about an inch wide and four or five inches long, and in each a store of pabulum is placed and an egg deposited. The earth removed forms those little heaps of mould always seen by the side of droppings where *stercorarius* is at work. The rounded further ends of the cavities are firmly packed with concentric layers of dung, in the centre of which a kind of cell is made, the Beetles apparently working with their fore tibiæ as trowels in making smooth the walls, and on the floor of this the egg is laid. The remaining part of the tunnel is packed with dung, layer by layer, before the work is completed.

Six species of Geotrupes are found in Britain, including the *G. Typhœus*, remarkable for the three horns projecting horizontally from the prothorax of the male. The genus is distributed over the whole north temperate zone, some of the species from South Europe and Japan being of bright coppery and golden colours. In Mexico and in Assam are found rare forms, having long vertical horns rising from the crown of the head. The allied genus *Bolbocerus*, of more spherical shape, and of pale reddish-brown colour, is most numerously represented in Australia, where the species exhibit great variety and eccentricity of form in the horns of the males: one species (*B. proboscideus*) having a long horizontal horn projecting from the head, slightly curving downwards, which simulates in miniature the trunk of an Elephant.

The sub-family Troginæ resemble the Geotrupinæ in the form of the head, but differ in the simple structure of the fore legs, which are not adapted for burrowing. The species live, in fact, on dried animal substances lying on the surface of the ground in sandy places, or on trees. Most of them are oblong or oval insects of moderate size, with rows of tubercles along the wing-cases, coloured like the sandy soil, and often coated with earthy material of the same colour. One group, however, which are found only on trees, and have the remarkable faculty of retracting their limbs, and closing themselves, like the Armadillo, into the form of little balls, are of polished metallic colours.

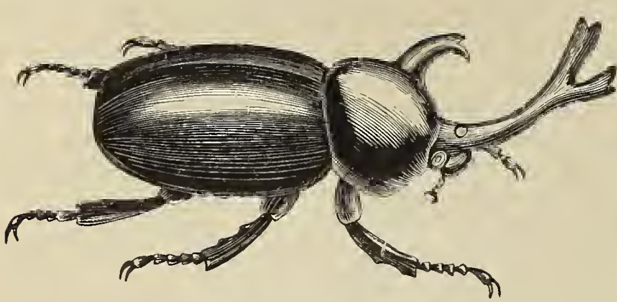
The sub-families of the Pleurostictica Legion are the MELOLONTHINÆ, or Cockchafers, the RUTELINÆ, or Goldsmith-beetles, the DYNASTINÆ, or Elephant and Rhinoceros-beetles, and the CETONIINÆ, or Rosechafers. All are vegetable feeders in both their larva and their adult stages—the great majority in their larva state feeding on roots of herbage, the remainder, including most of the Dynastinæ and Cetoniinæ, preferring decayed wood, some of the latter feeding on vegetable detritus in the nests of Ants. In their adult stages they offer more variety of habits. The Melolonthinæ are chiefly leaf-eaters; many of the Rutelinæ prefer fruit, although foliage and flowers are also resorted to; some of the Dynastinæ feed on succulent plants and the exudations of large forest trees; whilst the Cetoniinæ are pre-eminently Flower-beetles.

The Melolonthinæ are excessively numerous both in generic forms and in species, varying in size from a length of one-eighth of an inch to four inches. They are seldom of glossy metallic colours, the prevailing style of their livery being an integument of modest brown, coated with minute scales of white or grey, but sometimes of silvery or golden hue. Their organs of mastication are feebly developed, the mandibles being small, partly membranous, and not visible beyond the edge of the clypeus. The legs are long, with the hind tarsi formed of slender joints, and the claws, when both are present, as a rule divergent and toothed in the middle. Among the more remarkable subordinate groups of the sub-family we may mention first the *Hoplides*, small, compactly-built insects, with rich blue or silvery scale-clothing, distinguished by the more robust tarsi and the long unequal claws, very often reduced to a single claw curved like a grappling-hook. These are leaf and floral Beetles, of nimble flight, found in nearly all tropical and temperate regions, but nowhere in much abundance or variety except in South Africa, where some 300 species are met with, so varied in structure that no fewer than twenty-four genera have been found necessary for their classification. They are restricted to the southern extremity of the continent, comparatively few being found in the warmer district of Natal farther north, and, in short, they are the associates of the equally rich and peculiar flora of heaths and lilies of the Cape Colony. Another group, the *Sericides*, the most slenderly-formed of all the Melolonthinæ, of which we have two species in England, are copiously represented in Australia, where a numerous genus of gilded Chafers occurs, having a cleft clypeus, named *Diphucephala.* In America, North and South, the prevailing group are the *Macrodactylides*, elegantly-formed Beetles, with remarkably long and slender legs and feet, which are seen hovering in swarms over sweet-smelling flowers in open places on forest borders; a North American species feeds on the petals of roses. The typical group, *Melolonthides*, which includes our common Cockchafer and Midsummer-chafer (*Rhizotrogus solstitialis*), is feebly represented in South America, Australia, and Africa south of the Sahara; but is rich in large and handsome species in the north temperate zone, in tropical Asia, and Madagascar. To this group belongs a series of species in which the leaflets of the antennæ are increased in number and developed to an enormous length, especially in the males. One of the best known is *Polyphylla fullo*, a common insect in France, twice the size of the Cockchafer, and prettily variegated with marble-like markings of a chalky-white colour. In some North American species the body is striped with white.

MELOLONTHA VULGARIS (COCKCHAFER).

The Cockchafer (*Melolontha vulgaris*) seldom occurs in sufficient abundance in England to prove very destructive, either in its larva or perfect state. It is otherwise on the Continent, where, especially in France, it is developed in some years in countless myriads, the perfect insects stripping the trees of their entire foliage, and the larvæ destroying, by devouring the roots, not only the grass of pastures, but crops of all kinds of farm and garden produce, such as cereals, beetroot, strawberries, salads, and so forth. In a report on the ravages of the Cockchafer in 1865-6, presented to the Académie des Sciences in 1868, M. Reiset valued the damage done in the department of Seine-Inférieure in 1866 at more than one million sterling. The larva takes two years to complete its growth to the pupa stage, fourteen months of which are spent in active feeding, and ten months in dormant hibernation; the duration of the pupa state is eight months, and that of the adult Cockchafer three months and a half, three-fourths of which are passed underground, and one-fourth,

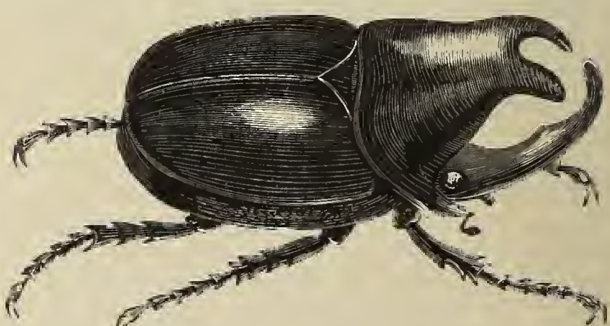
or twenty days, only in the free, devouring leaves, pairing, and depositing its ova. Like nearly all its tribe, it is active only in the twilight hours of evening, concealing itself by day among foliage. In the years when it is abundant it devours the leaves of fruit-trees in gardens and orchards, as well as its favourite elms and oaks, poplars and birch being the last to be attacked. Notwithstanding the attention with which this destructive insect has been studied in France, no definite means have been discovered of checking its ravages. Farmers have been recommended, as one means of lessening their numbers, to plough and harrow their fields in early autumn, when the grubs are closer together and lie nearer the surface of the soil, and hand-picking has been suggested, as well as the encouragement of such useful insectivorous animals as the Mole and Shrew-mouse, and the various carnivorous Beetles, such as the Carabi. In the United States of America an allied Beetle (*Lachnosterna quercina*), called the May-bug, is equally destructive to pasture land, and such is the completeness with which the larvæ do their work on the roots of grass, that turf may sometimes be peeled off in large sheets, like a carpet from a floor.



XYLOTRUPES DICHOTOMA.

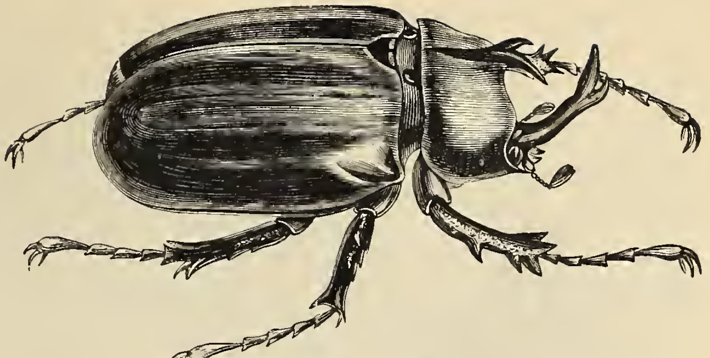
The *Rutelinæ*, or Goldsmith-beetles, differ from *Melolonthinæ* in their much thicker tarsi, the joints of which are articulated closer together, and in their claws being unequal in size and not divergent. They are mostly Beetles of polished metallic integuments, and diurnal in their habits, the strength of the legs and the form of their bodies enabling them to cling firmly to the leaves of trees when not on the wing. One large section of the group may be known by the membranous border of their wing-cases. To these belongs the genus *Anomala*, of which about two hundred species are known from various parts of the world, one (*A. Frischii*) being a well-known British Beetle. Some of the large tropical American *Rutelidæ* are amongst the most brilliantly-coloured Beetles in existence : such are the species of the genus *Plusiotis*, whose burnished hides in some cases resemble silver or gold both in colour and texture. They are found on oaks in the mountains of Central America.

The *Dynastinæ* are nearly all of sombre black or dark brown colours. The smaller species (*Cyclocephala*, *Ligyrus*, *Heteronychus*) show at most only the rudiments of the enormous horn-like processes with which the larger species are adorned. These weaker members of the group occur sometimes in tropical countries in countless swarms, especially in the sultry evenings which introduce the rainy seasons. At those times the town of Santarem, on the Amazons, is visited by such multitudes, attracted apparently by the lights of houses and shops, and flying with such speed, that the effect is like the pelting of a violent hailstorm. *Cyclocephalæ* frequent in large numbers the gigantic spathes of plants of the Arum family at the period of flowering, wallowing in the sticky pollen, and most likely serving in the cross-fertilisation of the plants as they pass from one to another. *Ligyrus bituberculatus* feeds on sugar-cane, and is known to be at times destructive to plantations in Demerara. *Xylotrupes gideon* and *Oryctes rhinoceros* attack the cocoa-nut palm in Malacca. Among the great horned species, which are equally abundant in the warmer countries of the New and Old Worlds, we give as illustrations, *Xylotrupes dichotoma*, from China and Japan, *Megaceras chorinæus*, from Cayenne and the Amazons, and *Megasoma typhon*, from Brazil. Others are known with much larger horns, such as *Dynastes hercules*, from Guiana and the West Indies, with its tapering thoracic horn projecting horizontally, and larger than all the rest



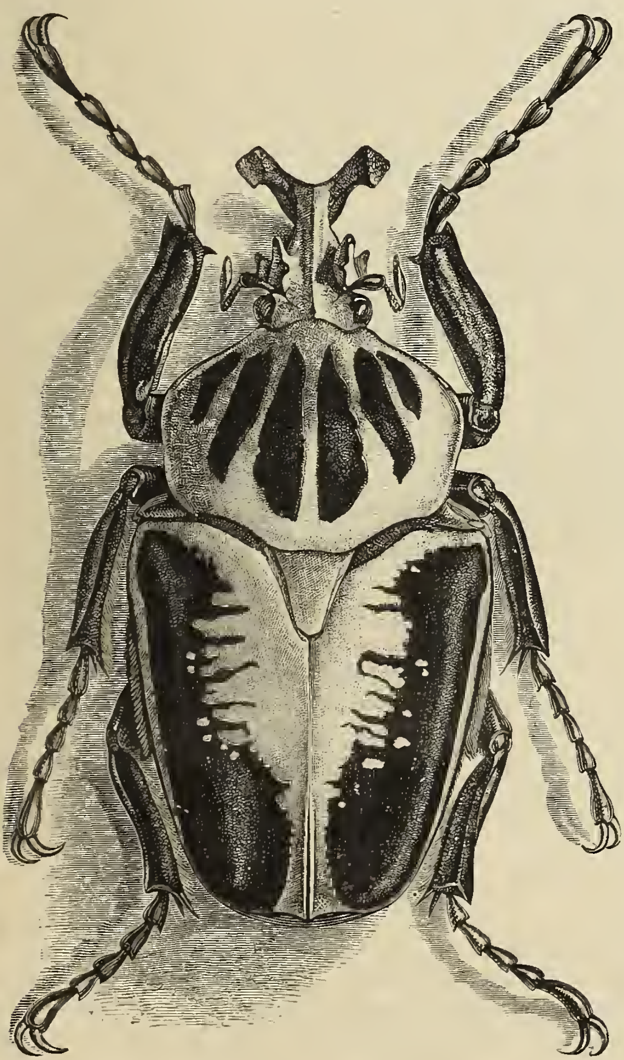
MEGACERAS CHORINÆUS.

of the body, and the still more extraordinary *Golofa Porteri* of New Granada, in which the horn rises vertically several inches high from the prothorax. The dark-bronzed *Chalcosoma atlas*, with long and sharp horns, three in number, rising from head and thorax, well known to collectors, is from the islands of the Malay Archipelago.



MEGASOMA TYPHON.

The *Cetoniinæ*, or Rosechafers, are easily recognisable by their oblong, usually somewhat flattened form, the generally large triangular scutellum and the wing-covers not covering the apex of the abdomen. They are further distinguishable, on closer examination, by the upper lip being concealed under the front edge of the clypeus, and the mandibles reduced to thin membranous blades, with a narrow outer margin alone horny. The typical or true Cetoniinæ have a still more conspicuous distinguishing character, in the side piece of the mesosternum (or middle breast) being elevated, and introduced between the hind angles of the prothorax and the wing-cases. But this character fails in the group *Trichiides*, which forms the second division of the sub-family.



GOLIATHUS DRURYI. (*Natural Size.*)

The *Cetoniinæ* are the favourite group of Beetle collectors, a distinction they well merit for their unsurpassed beauty of form and colour, the facility of their preservation, and the great numbers and diversity of their species. To the classifier, however, they are less satisfactory, for all the structural characters on which he depends for the definite arranging into genera and higher groups prove here to be extremely unstable. At most, a few groups can be indicated by the agreement of their general figure, or "facies." About 1,200 species have been described. These are moderately numerous, and of little variety of form, in north temperate latitudes; in the corresponding zone of the south, as well as in oceanic islands generally (including New Zealand), they are entirely wanting. But each of the continents and large island groups within the tropical and warm temperate zones contains numerous peculiar genera, the richest being tropical Africa, Madagascar (which has a set of types distinct from those of Africa), tropical Asia, the Malay Archipelago, and Australia. America is relatively poor in Cetoniinæ, but possesses its own very characteristic genera.

At the head of the sub-family stand the Goliathides, or Goliath Beetles, distinguished by their large size, the horny processes with which the heads of the males are adorned, and the teeth-bearing lower jaws, or maxillæ. Their head-quarters are tropical and Southern Africa, some few genera being peculiar to tropical Asia. Our figures represent *Goliathus druryi*, from the Gold Coast, the largest of all the species, which is found by the negroes feeding at the sap of trees in the forest, and *Ceratorhina polyphemus*, an inhabitant of the wooded region extending from the Gold Coast to the Gaboon and Congo, and met with as far in the interior as the Muata Yanvo's domain in Central Africa. More than thirty species of Ceratorhina are known, one of the most beautiful of which (*C. Petersiana*) has been taken at a village on the River Shiré, near Lake Nyassa, flying in great numbers about the flowers of a lofty tree, under which the native *palavers* are held. The ground-colour in these insects is a rich silky green, varied with stripes and spots of snow-white felted pile. The Madagascar series of forms consist chiefly of the *Schizorhina* group, destitute of horns, but having the front edge of the clypeus more or less notched. The same group constitutes the bulk of the Australian forms; but in the north, and in New Guinea, an allied group, called *Lomaptera*, of large size and great splendour of colour, is very numerous. The well-known European *Cetonia aurata*, common in our southern counties, may be taken as a fair representative of the general form of the Cetoniinæ. In England it is found on various flowers, chiefly roses, hawkweeds, and other compositæ, in June and July, readily taking wing, and flying, like its congeners, with the wing-covers closed, instead of wide open like the majority of Coleoptera, a peculiarity due chiefly to the protrusion of the side-pieces of the breast, already alluded to, in front of the shoulders of the elytra. The larva lives in decayed wood, and in the vegetable accumulations of Ants' nests, fabricating a sort of cocoon with agglutinated particles of the wood, in which to pass its transformations; and the duration of a generation, as in the Cockchafer, is three years. The second section of the sub-family, the *Trichiinæ*, are much less numerous than the Cetoniinæ, but some of their species are equally handsome. One of the largest (*Inca clathrata*) inhabits Brazil.

CERATORHINA POLYPHEMUS.

TRIBE SERRICORNIA.

The Serricornia form a numerous tribe of Beetles of elongate shape, furnished with antennæ short or of moderate length, most of the joints of which are more or less prolonged on the inner side, so as to give to the organ the appearance of a saw, or, when the prolongations are of greater length, of a comb. The tarsi, always five-jointed, are very often dilated, each joint (except the terminal one bearing the claws) being heart-shaped, or, as in many cases, furnished beneath with a membranous appendage. The head is almost always retracted up to the eyes within the prothorax, and this latter member is locked to the hind body by the projection of the prosternum being received into a cavity of the mesosternum. Thus, though often of great length and slenderness, the body in these insects is well knit, and adapted for movements of considerable vivacity and precision. The whole are vegetable feeders, but the larvæ and their habits offer much diversity, which will be further detailed under the head of the respective families.

FAMILY BUPRESTIDÆ.

This family is distinguished from the others of the same tribe by the fixity of the interlocking of the prosternum with the mesosternum, and by the solidity of their integuments and the short serrated antennæ. They are remarkable for the great beauty of their colours and markings, no other family containing so large a proportion of bright metallic-coloured species; and they are further remarkable for the uniformity of structure and general figure which characterises them as a group, notwithstanding the enormous number of their specific forms, of which nearly 3,000 have already been described. In

their habits also they offer little variety; the perfect insects, in the great majority of cases, frequent the trunks and large branches of felled trees in wooded regions. Here they may be seen sometimes in great numbers, nimbly walking over the bark or flying with great speed from tree to tree in the hot sunshine, and pairing, the females depositing their eggs in little cavities nibbled by them for the purpose. The larvæ of these typical species are elongated, somewhat flattened, pale, fleshy grubs, having the first of the thoracic segments abruptly widened, and only one pair of feet. On emerging from the eggs, the larvæ feed on the young wood between the bark and the solid trunk, undergoing in these places their transformations, or burrowing as they grow in size to the interior. Such are the habits of the majority of the family, including most of the larger and handsomer species of our museums. The smaller and broader species, forming the sub-family *Trachydinæ*, differ much from the others, both in their larval form and their habits, the larva having six minute feet, and a horny plate on each of the abdominal segments above and beneath, the widest part of the thorax being at the middle segment instead of the first. In its habits it differs further in feeding on the parenchyma of leaves. Although the Buprestidæ are peculiarly forest insects, the northern species affecting the timber of coniferous trees, some have passed over to the cultivated trees of orchards. Thus, two species of Chrysobothris, *C. femorata* and *C. harrisii*, sometimes prove destructive to apple-trees in North America. As examples of this family, we figure *Cyria imperialis*, an Australian species, and *Chalcophora mariana*, a common insect in Central and Southern Europe. The species found in the British Islands are few in number and of small size.

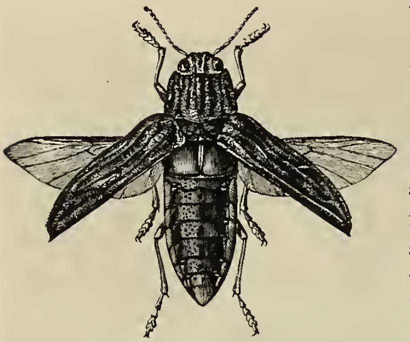
CETONIA AURATA (ROSECHAFER).

CYRIA IMPERIALIS.

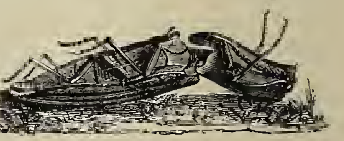
FAMILIES THROSCIDÆ, EUCNEMIDÆ, AND ELATERIDÆ.

Two small families, THROSCIDÆ and EUCNEMIDÆ, hold an intermediate position between the great group BUPRESTIDÆ and the equally numerous ELATERIDÆ. The Throscidæ are small insects, resembling the Buprestidæ in the intimate union of the various parts of the body and the form of the interlocking apparatus of the fore and middle

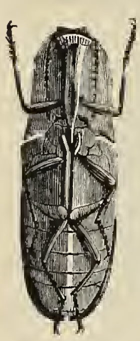
sterna. Their antennæ are received in repose in narrow furrows existing for their protection in the sides of the prosternum, and their feet are contractile. About a hundred species are known, chiefly from South America. The EUCNEMIDÆ are distinguished by their nearly cylindrical form, and the close approximation of the cavities in which the antennæ are inserted, which has the effect of greatly contracting the forehead. The antennæ are often beautifully branched. Nearly 500 species are known, chiefly from tropical countries. The ELATERIDÆ are more abundant in temperate latitudes than either of these two families, the species of our own country being familiarly known as "Click-beetles," from their singular habit of springing up in the air with a clicking noise when held in the hand on their backs, and thus, by reversing themselves, recovering the walking position. This action is produced by a vigorous tension of the muscles connecting the prothorax with the hind body, which raises the back above the surface on which the body lies, followed by a sudden relaxation, which brings it down again with force sufficient to make the insect bound into the air. The long, narrow, and flattish body, and the short and slender legs of these Beetles, render it otherwise very difficult, or even impossible, for them to turn over when by any accident they are cast on their backs. In accordance with this peculiar habit the sterna are not permanently interlocked, as in the Buprestidæ, but the long spine of the prosternum and the corresponding groove of the middle breast play a necessary part in the saltatory movement, in bringing the parts together after the strain and elongation of the thoracic muscles, the groove helping to guide the projecting point into the true axial position immediately the insect brings its prothorax down again and bounds upwards.


CHALCOPHORA MARIANA.

The Elateridæ are well known also in their larva stage as the redoubtable Wireworms of our farmers and gardeners. These derive their name from their long, slender, cylindrical, somewhat rigid forms, so different from the club-shaped grubs of the Buprestidæ. They are generally wood-feeders, abounding often in rotten stumps; but many species are root-gnawers, and in this capacity attack all sorts of cultivated vegetable produce—the grass of lawns, cereals, and the plants of our gardens. Some of the species have been observed to live three years in the larva state, and to do in this time great damage to crops of corn.


ELATER PREPARING TO SPRING.

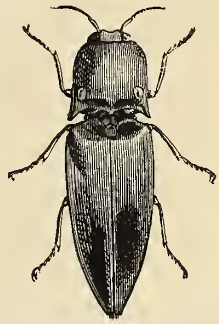
A remarkable faculty of one group of these insects is their luminosity: the Fire-fly of the West Indies and South America belonging to this family, and not to the true Glowworms. The light is emitted from two rounded spots on the prothorax, which are covered with a thinner and paler horny coating than the rest of the integument. Underneath each of these lamp-covers, within the thorax, is a vesicle of phosphorescent substance, which is luminous or not according to the will of the insect. The fire-flies belong to the genus *Pyrophorus*, and about ninety species are known from North and South America, differing in the degree of luminosity, some being destitute of lamps visible on the exterior. They are all night-flyers, and much less abundant than the true Glow-worms of the same countries. The light is in some species emitted from the membranous parts at the articulation of the segments of the thorax, as well as from the rounded spots on the surface. Luminous Elateridæ, distinct as a genus from *Pyrophorus*, are found also in the New Hebrides Islands in the South Pacific. The larva of an Elater of the genus *Melanactes*, found in the United States, is also phosphorescent. We figure one of the *Pyrophori*, and also a North American species, *Alaus oculatus*, which has two eye-like spots on the prothorax, but is not luminous.


JUMPING ORGAN OF ELATER.

Allied to the Elateridæ are the two families CEBRIONIDÆ and RHIPICERIDÆ, the latter of which has in the males beautifully branched, sometimes fan-like or flabellated, antennæ. The middle sternum has no groove for the reception of a projection of the fore sternum. A few species only are known of either family, and none occur in the British Islands.

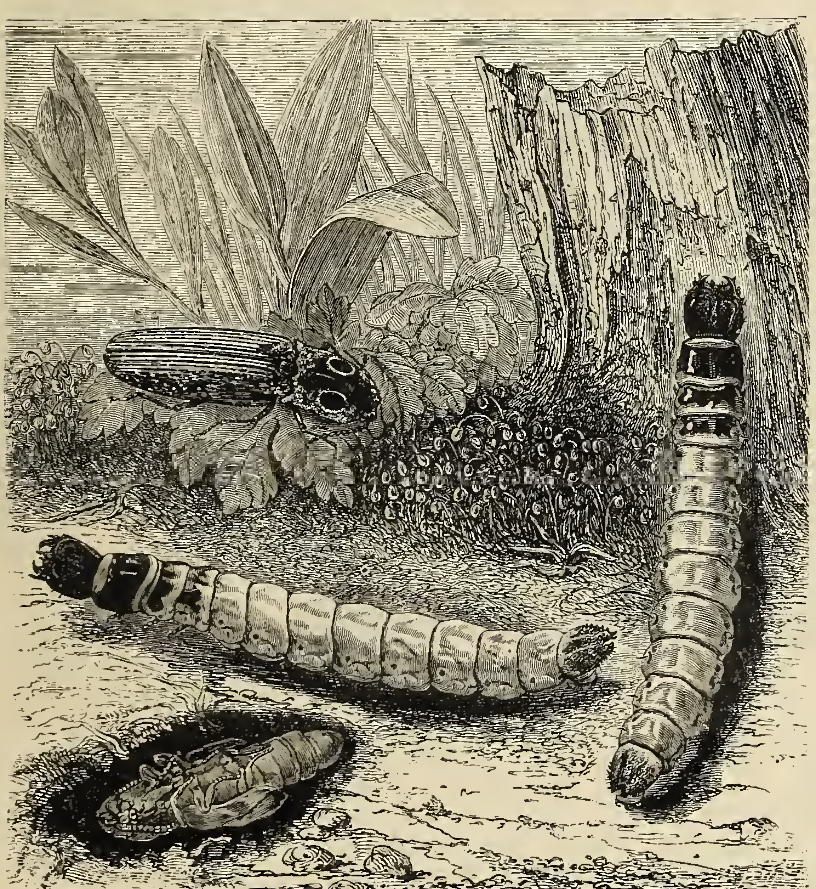
TRIBE MALACODERMATA.

Under this tribe are ranged a number of families which are distinguished for the softness or flexibility of their integuments and the absence of interlocking apparatus, and the consequent greater freedom of movement of the prothoracic division of the body. The antennæ are very variable in form, often thread-like and sometimes serrated, but rarely clavate; and the haunches of the anterior and middle pair of legs in all the typical species are salient and conical, in agreement with the general loosely-knit structure of the whole framework. The habits of the species are variable, and will be mentioned under each family and tribe. The larvæ differ greatly from those of the Buprestidæ and Elateridæ, in being of somewhat flattened form, and possessing firm or horny integuments; and in this stage carnivorous propensities seem to be generally characteristic of the tribe, although a large number in the adult stage are floral Beetles.



PYROPHORUS NOCTILUCUS (WEST INDIAN FIRE-FLY).

The two chief families of the tribe are the Dascyllidæ and the Malacodermidæ, or Malacodermata proper, the former consisting of species of oblong or oval form, with five abdominal segments, a more solid consistence of body, and the mentum, or chin, especially of horny texture; the latter of elongate, soft-bodied Beetles, with the mentum, or chin, often indistinct, blended with the membranous ligula, or tongue, and the abdomen formed of six or seven free segments—characters which indicate a very low type in the Coleopterous series. Some of the insects belonging to this family are among the best-known of the whole order. Such are the Glowworms and the *Telephori*, or "soldiers and sailors," so abundant in gardens in the early days of summer.



ALAUS OCULATUS.

The first sub-family are the *Lycinæ*, Beetles of elongate flattened form, very generally widening behind, and of red or tawny-yellow colours, banded with black. About 400 species are known, chiefly from the warmer regions of the earth, only three, belonging to the genus *Eros*, being found in the British Islands. The adult insects are met with chiefly on the leaves of trees, but *Eros minutus* in England is taken in rotting branches of oak. The second sub-family are the Lampyrinæ, or Glowworms, distinguished from their allies by the prothorax forming a shield more or less

covering the head, and by their power of emitting light. This striking phenomenon, which has attracted popular attention in all countries where species of the family are found, is due, as in the Fire-flies, to phosphorescent particles concentrated in certain parts of the body. In the Fire-flies the sacs of luminous matter are contained in the prothorax; in the Lampyridæ they are localised in two or three of the abdominal segments. The two eminent anatomists, Kölliker and Macaire, are agreed that the granules which give forth the light are of albuminous nature; but Matteucci has assured himself by chemical analysis that they do not contain phosphorus. He says the luminous granules form part of a yellowish pulpy tissue lying underneath the transparent plates of the abdomen, which are visible in all Lampyridæ possessing the faculty, even in the dried specimens. This mass of tissue is permeated with nerves, and with ramifications of fine tracheæ, or tubes: the one supplying the air to feed the combustion which goes on when the light is shining, and the other the stimulus of the will of the insect. This description applies to the common European species (*Lampyris noctiluca*), abundant in many of our southern counties. In this, as is well known, the female is wingless, resembling, in fact, the larva state of the species, and gives forth a more brilliant light than the winged male. In very many exotic species both sexes are winged, some of the larger ones emitting a very conspicuous light, which, when many hundreds are seen at once—as often happens on dark sultry nights in the tropics—form a very beautiful sight, the phosphorescent lamps glittering in the bushes, or slowly moving and inter-crossing in the air, as the insects fly from tree to tree. Observers are agreed that these lamps serve as beacons to attract the sexes to one another; and the Rev. H. S. Gorham, who has studied a great diversity of species belonging to the family from all countries, made the curious observation that the different species vary greatly in the area of the luminous surface and in the size of the eyes, and that the eyes are developed in inverse proportion to the luminosity. He further remarks that wherever the light-emitting surface is confined to small spots only, and the eyes also are small, the antennæ present a high degree of development, being plumose, or branched like a feather, a structure which admits of a large extent of sensitive, probably auditory, surface, a change of form the more significant, inasmuch as the Lampyridæ with large eyes, or with a high degree of luminosity, have simple and often short thread-like antennæ.

LAMPYRIS SPLENDIDULA.

All known Lampyridæ are nocturnal in their habits, concealing themselves by day under dead leaves or about the roots of herbage. They are supposed to be vegetable feeders in their adult state; but the larvæ are carnivorous, feeding on land molluscs, in the interior of the shells of which the insects may often be found. The species we figure is the *Lampyris splendidula*, an inhabitant of Central and Southern Europe. Upwards of 500 species of this family are known, by far the greater number belonging to America, North and South.

The sub-family Telephorinæ consists of species having a more elongated and narrower form than the preceding, with longer legs, and head not covered by the prothorax; one of the genera which connects the sub-family with the Glowworms is luminous. The family is abundantly represented in

temperate regions, twenty-five species of the genus Telephorus alone being found in Britain. The smaller species belonging to the genera Malthinus and Malthodes, often marked by pale spots at the tip of the wing-cases, are met with in abundance in hawthorn blossoms in spring. The next sub-family (Drilinæ) contains a small number of species only, those whose habits are known, such as *Drilus flavescens,* resembling the Glowworms in having wingless females, and feeding in the larva state on Snails. On chalk hills in our southern counties it may be met with occasionally in the shells of the common *Helix nemoralis.* These insects differ in structure from the Lampyridæ, the head being free, and the antennæ inserted in front of the eyes. Following them are the numerous sub-family Melyridæ, of which we have in Britain six genera and seventeen species. They are floral Beetles, generally of metallic colours, and sometimes hairy. The species of Malachius are recognisable by their abbreviated wing-covers, spotted with red at the tip, and the curious small fleshy vesicles of red or orange colour which are protruded by the insects from the sides of the thorax and abdomen.

FAMILIES CLERIDÆ, PTINIDÆ, AND BOSTRICHIDÆ.

Associated with the Malacodermata by some authors are three families, which differ from the general character of the tribe in having integuments of normal horny consistence. The first are the Cleridæ, a numerous group, infinitely varied in colours and markings, and presenting many singular modifications of important organs, such as the antennæ. Amid all their varieties of form and structure, they may be distinguished from the Melyrinæ (their nearest allies), and from other groups of Malacodermata, by their tarsal joints being furnished beneath with flattened membranous appendages, and by the haunches of their hind legs articulating in transverse sockets. Nearly 800 species are known, from nearly all parts of the world; some, such as *Necrobia rufipes* and *ruficollis*—metallic-blue or green hairy insects, with red thorax or red legs, and clubbed antennæ—being among the most widely-distributed of all known insects, as they feed upon dried animal substances, bones, and the remains of food, and accompany civilised man in all his wanderings. Some of the larger species, belonging to the genus Trichodes, are of metallic colours, with wing-cases banded or spotted with bright red or orange. Many of these are common in Europe, and are well known for the destruction they cause in hives of the Hive Bee, as well as various kinds of social Wild Bee, their larvæ devouring the newly-hatched grubs of the Bees in their cells. Carnivorous propensities seem to be universal in this family, at least in the larva state; and even the gaily-coloured, innocent-looking adult Beetles, although frequenting flowers, are often noticed to seize and devour soft-bodied insects. A large proportion of the species, however, belonging to *Epiphlœus* and allied genera, differing from the rest by their russet and inconspicuous colours and markings, are seen only on the trunks and branches of newly-felled trees, their larvæ living under the bark, and feeding on the larvæ of bark insects. Here the perfect Beetles may be found in tropical countries in the bright sunshine, running about with great agility, and vieing with the green and gold-spangled Buprestidæ in activity. Many others, such as the long, slender *Priocerœ,* which have serrated antennæ, are found slowly moving about the leaves and slender twigs of trees; and others (Hydnocera, with short thread-like antennæ, clubbed at the tip, and many of the Enopliinæ) infest the broad-leaved Heliconiæ and Marantaceous plants in American forests, running over the leaves, and preying on small Phytophaga. All the known larvæ resemble closely those of the Melyridæ, thus proving the close affinity of the two groups.

The Ptinidæ are convex, oval, or rounded insects, with generally longish filiform antennæ. They breed in dead wood, and are often very destructive in their larva state, especially to furniture in houses and warehouses. The Bostrichidæ are of cylindrical form, with the three terminal joints of the antennæ forming a club, and are recognisable by the great convexity and roughened surface of the front part of the thorax, which hides the head when the insect is viewed from above. They are wood-eaters, and amongst the most efficient agents in the destruction of trees in the countries where they abound. One species (*Sinoxylon sexdentatum*) is sometimes very destructive to the grape vine in the south of France.

CHAPTER V.

SECTIONS HETEROMERA, TETRAMERA, AND TRIMERA.

SECTION HETEROMERA: Beetles with Five-jointed Tarsi to the Four Anterior, and Four-jointed to the Two Posterior Legs—Division of the Heteromera into Atrachelia and Trachelia—Habits—Churchyard Beetles—Blister Beetles—Hypermetamorphosis—Singular Parasitic Habits and Mode of Development of *Sitaris*, *Meloë*, *Cantharis*, *Rhipiphorus*, *Hornia*, *Rhipidius*, and the *Stylopidæ*—SECTION TETRAMERA: Beetles with Four-jointed Tarsi—Family CURCULIONIDÆ, or Weevils—Family SCOLYTIDÆ, or Bark Beetles—Habits of some of the British Species—Families BRENTHIDÆ, ANTHRIBIDÆ, and BRUCHIDÆ (Seed-borers)—Tribe LONGICORNIA—Great Beauty and Variety of Form and Colours—Night-flying and Day-flying Longicornia—Musk Beetles—Gigantic Species—Mimetic Resemblances and Protective Disguises—Branch-sawyers—Popular Errors on the Subject—Tribe PHYTOPHAGA, or Leaf-eaters—Strange Habits of some of their Larvæ—Family EROTYLIDÆ—SECTION TRIMERA: Beetles with Three-jointed Tarsi—Lady-birds.

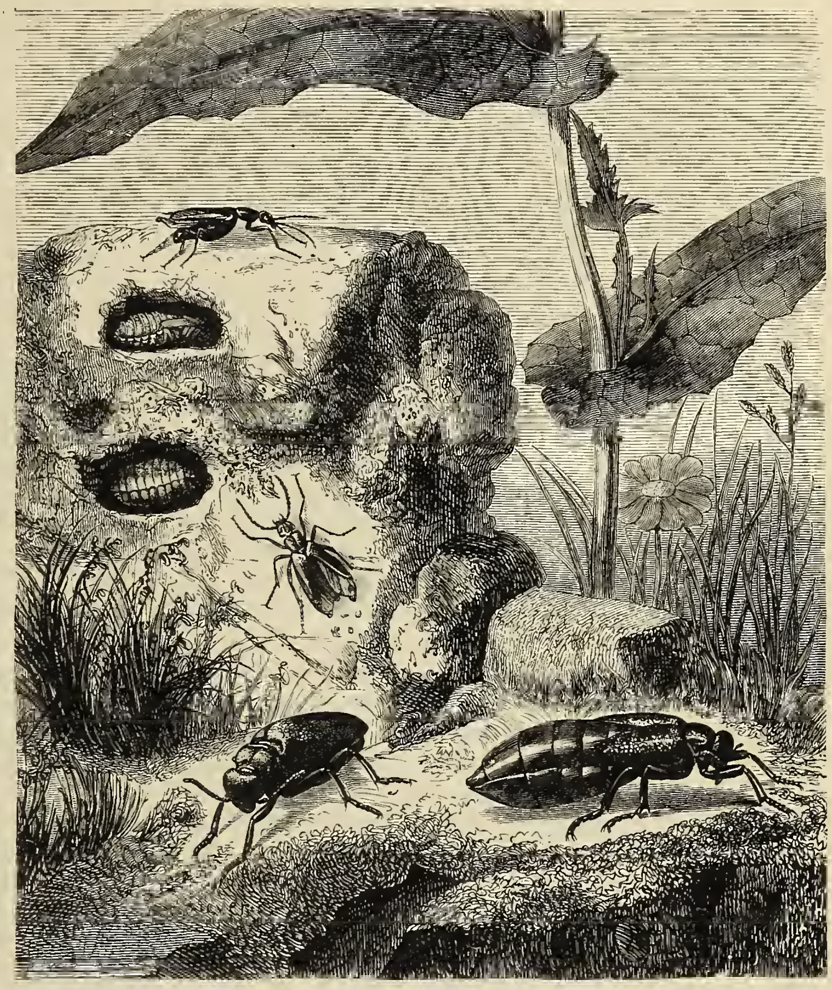
SECTION HETEROMERA.

THE Heteromera, Beetles with five tarsal joints to the first and second pairs of legs, and four joints to the third pair, were divided by Westwood into two sub-sections, under the names of Atrachelia and Trachelia, the former including a host of forms of prevailing dull black colours (though some genera are metallic) and solid integuments, with the head sunk in the prothorax, the latter comprising all the remaining families, and distinguished by the exserted head, softer integuments, and more varied coloration.

The ATRACHELIA form the single family TENEBRIONIDÆ of recent entomologists, one of the most numerous of the whole order, about 5,000 species having been described. Notwithstanding their number, and the great diversity in subordinate points of their structure, they have all a common air of parentage, which renders their recognition easy, and the general similarity is extended even to a peculiar and disagreeable odour which they emit. Nearly all are ground Beetles, inhabiting sandy districts about the roots of herbage or under vegetable detritus, feeding on these or on animal substances, and being nocturnal in their habits. A few live under the bark of trees and in boleti. The brighter metallic-coloured species live on trees, and are active by day. Some of the hard-bodied genera are known for their extreme tenacity of life, the most interesting example of which is that of a specimen of *Zopherus bremei*, an insect about an inch in length, and of stony hardness of integument, which was exhibited alive by Mrs. Randolph Clay at a meeting of the Entomological Society of London, about a year after she had received it from Mexico. It was carried on her shoulder, secured by a gold chain round its waist, and had not tasted food since it had been in the possessor's hands. The family are remarkable for the mimetic resemblances which many of their species present: the form and garb of genera of other families, and particularly of the predaceous group Carabidæ, or of the lignivorous Longicornia, being most frequently assumed. The resemblance is so close in some cases that it is only by counting the joints of the hind tarsi that the true nature of the insect can be detected, without the dissection of the mouth. Preferring open, sandy districts, scantily or not at all wooded, the family is most numerously represented and most varied in comparatively desert regions, such as the borders of the African, Persian, and Central Asian deserts, the interior of North America, and the drier parts of Chili. Among the few species found in the British Islands, the most remarkable are *Blaps mortisaga*, or "Churchyard-beetle," *Helops pallidus* and *striatus*, and *Opatrum subulosum*, met with on sand-hills by the sea-shore.

The Trachelia are less homogeneous than the Atrachelia, and have been divided consequently into numerous families. The first of these, the CISTELIDÆ, are slender arboreal insects, with pectinated tarsal claws. The NILIONIDÆ resemble certain convex Nitidulidæ, and are found in boleti in tropical America. The MELANDRYIDÆ and PYTHIDÆ are composed of a small number of species, inhabiting chiefly the north temperate zone of the New and Old World. Some of the latter, forming the genus Salpingus, have the head prolonged into a snout, and bear some resemblance to Weevils. The ANTHICIDÆ are minute, agile Beetles, bearing a wonderful likeness to Ants; many species are found in our own country, chiefly running over vegetable *débris* in sandy situations. Next to these comes a series of families allied to the Blister-beetle of commerce, some of the species of which are parasitic on other insects in their early stages, and exhibit the extraordinary phenomenon called *hypermetamorphosis*, that is, they undergo more than the normal number of changes in their growth from the newly-hatched grub to the pupa stage. This abnormal metamorphosis is connected with, or necessitated by the peculiar conditions of their parasitic life, and presents features of great interest.

The first complete observations on the subject were made by M. Fabre, who studied the development of *Sitaris muralis* (family MELOÏDÆ) with great perseverance and success. The Beetle is a well-known British as well as continental insect, and was long suspected to be parasitic on the common Mason Bee, in the sense of living, in the larva state, on the food stored up in the cells of the Bee. M. Fabre discovered that it feeds on the eggs of the Bee as well as on the provision of honey stored up for the young, undergoing a singular change of form in the interval between the two operations, besides other metamorphoses, before assuming the ordinary pupa condition. The female Sitaris, in the summer, lays her eggs in a mass glued together, at the entrance of the cylindrical gallery in a wall or bank within which the mother Bee constructs her cells. In the course of a month the young crawl forth in the form of little, elongated, six-footed larvæ, each foot terminated by a very sharp and movable claw, and the abdomen, near its tip, provided with two horny hooks. Contrary to all natural expectation, these larvæ, instead of searching for food straightway, remain for months fasting and motionless, until, in the early spring of the following year, the early Bees (always of the male sex) begin to emerge from the hole; then in an instant the sleepy larvæ start up, and fasten themselves with their strong grappling-hooks to their hairy bodies. From the male Bees they quickly pass, during union of the sexes, about a month later, to the females, and thus get conveyed to the newly-made cells, where, after the mother Bee has stored up a provision of liquid honey and laid an egg on the surface, the hungry larva slips off the Bee's body to the egg; in doing which it dexterously contrives to avoid being rolled off into the liquid, where it would infallibly perish. Alighting on the egg it quickly tears it, and commences to devour its contents. The repast lasts eight days, during which the little animal grows rapidly, and at the end, having completed its growth, and still mounted on the empty egg-shell as a raft, its skin splits down the back, and it enters its second stage. It is now a soft white grub, blind, and provided with only rudimentary feet. It has changed, in fact, from an active carnivorous insect into a blind and helpless honey-feeder, adapted to the condition in which it is placed, of having food in abundance without the need of searching for it. It tumbles off the egg-shell into the honey,



1, MELOË CICATRICOSUS. 2, SITARIS MURALIS.

without risk now of being drowned, for all its breathing-holes are situated on the dorsal surface of the abdomen, and the ventral part alone is submerged. Thus it wallows until, having consumed all the honey, it undergoes another change, into what M. Fabre calls a "pseudo-chrysalide," a maggot of peculiar angular form, which remains motionless throughout the winter, and in spring changes its skin and appears as a larva again, completely resembling the form it had in the second stage. But it takes no nourishment, and in a short time changes into a pupa of the ordinary Coleopterous type, from which the winged adult Sitaris emerges at the end of a month. The whole series of wonderful changes occupies two years.

The other species of parasitic Meloïdæ that have been observed have analogous, but in some points different, transformations and habits. Thus the species of Meloë, or Oil-beetle—of which one or two are common in spring on hedge-banks in many parts of England, and are recognisable by their short wing-cases, blue-black colour, voluminous abdomen, and greasy appearance—lay their eggs in holes in the ground previously excavated, and the larvæ, when hatched, attach themselves to Bees of various species. The only Bees on which they can profitably settle are such as make a provision of pollen-paste; and the active six-footed larva of the parasite, on completing its growth, changes into a fleshy cylindrical grub, with less aborted legs and stronger jaws than the corresponding stage of Sitaris. The parent Meloë lays an immense number of eggs, in little agglutinated masses and in many different holes, and the newly-hatched larvæ, climbing the stems of flowering plants, attach themselves with so little discrimination to any living hairy insect—Diptera or useless Hymenoptera—that large numbers perish by failing, through their faulty instinct, to be conveyed to cells where a store of pabulum is provided.

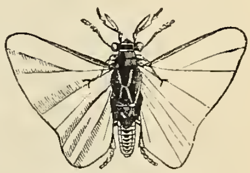
Certain genera of this family, more nearly allied to the Blister-beetle (*Cantharis vesicatoria*), and most probably some of the true *Cantharides* themselves, are parasitic on the eggs of Grasshoppers or Locusts, which it must be remembered are laid in masses enclosed in a cocoon-shaped envelope, aptly termed "egg-pod." The discovery of this singular variety of parasitism is due to Mr. C. V. Riley who followed up the first indications he met with by a most complete series of observations on numerous species, both of Blister-beetles and Locusts, in the United States. The Beetles were, the *Epicauta cinerea*, *pennsylvanica*, *vittata*, and *marginata*, and the *Macrobasis unicolor*, Blister-beetles which, in their adult states, feed on the leaves of the potato. Their prey was the Rocky Mountain Locust (*Caloptenus spretus*) and other Grasshoppers of the same genus. He found that the parent Beetles lay their eggs, like the Meloë, in holes which they scratch in the ground, preferring the same warm sunny localities as the Locusts. The larvæ, in their first stage, somewhat resemble those of *Sitaris*, but are larger, more spiny, and have more powerful head and jaws and longer legs; strength and activity, in fact, are necessary to the creatures, who have to prowl about often for many days before finding the eggs which are to constitute their food. An egg-pod found, they precipitate themselves upon it with the utmost eagerness, fighting amongst themselves to the death for its exclusive possession, and gnawing their way through the shell to the contents. On becoming full-fed, about the eighth day, the active larva changes its skin, coming forth as a soft grub, with short legs. In this state it naturally lies in a curved position, but is active, and goes on feeding for about another week, when a second moult takes place, and it emerges as a more obese grub, with rudimentary legs, which is not materially modified a few days afterwards, when a third moult supervenes. In this last stage it grows apace, feeding continually on the rich juices of the Locust eggs, until at the end of another week it leaves its pabulum and burrows at some little distance in the clean soil, where it undergoes a transformation into the "pseudo-chrysalide" stage, in which the parts of the mouth become quite rudimentary, and no nourishment is taken. The insect generally hibernates in this stage, changing its skin in the spring, and coming forth again as an active larva, but only to burrow about in the ground, not to feed, and in the course of a few days changing into the true pupa, whence in a few days more the perfect Beetle emerges.

A further modification in the parasitism of this singular group is seen in *Rhipiphorus paradoxus*, a British species, whose life-history has been traced with great patience and acumen by Dr. Algernon Chapman. This insect feeds on the grub or larva of the Wasp. The mother Rhipiphorus lays her eggs in the cells of the Wasp, and the larva, on its emergence as a black active hexapod, similar to the first stage of Meloë larvæ, eats its way into the nearly full-grown grub of the Wasp, and feeds for some

time in the interior, without killing it, emerging after the grub has spun up for the pupa state. It then changes its skin, and comes forth in a shorter and thicker form, in which stage it attaches itself to the upper part of the body of its victim, and feeds by suction, soon afterwards undergoing a second change, and finally devouring the undeveloped Wasp entirely. When full-grown the Rhipiphorus larva closely resembles the grub of a Hymenopterous insect of the family of Fossorial Wasps.

In the *Hornia minutipennis*, another parasitic Meloïd, discovered by Mr. Riley infesting the cells of Mason Bees, the wing-covers in both sexes are reduced to minute scales on the sides of the middle segment of the thorax. This tendency to disappearance in the organs of flight is carried still further in *Rhipidius blattarum*, a minute European Beetle parasitic on the bodies of living Cockroaches, the female of which is apterous, and differs little in appearance from its larva, whilst the males have short divergent wing-covers and membranous wings. From this curious little Heteromeron, which feeds within the bodies of its victims, the transition is not unnatural to the family Stylopidæ, a group of minute insects, which until recently were believed by all entomologists to constitute a distinct order of insects (Strepsiptera), differing from all others in the form of their wings, the parts of their mouth, and the relations between the segments of their thorax.

The Stylopidæ are parasitic on living Bees and Wasps, the females being apterous and larviform, residing permanently in the bodies of the insects they infest, the males winged and active. The latter live but a few hours, and solely for the purpose of aiding in the propagation of the species, seeking the females, whose bodies are imbedded, with the exception of a small upper portion, in those of Bees as they fly from flower to flower, and the orifice of whose reproductive organs lies in the exserted part near the head. The males take no nourishment during their short lives, and their mouth-organs are in a rudimentary condition, only the mandibles and one pair of palpi being recognisable. The head is extremely short and broad, the eyes prominent, the antennæ curiously forked, and the two anterior segments of the thorax relatively shorter and more closely connected together than in any other group of the Coleopterous order. But the most striking features are the greatly expanded membranous wings, coupled with the arrested development of the elytra, which do not serve as wing-covers, but are reduced to the form of slender appendages of thin texture, which in the dried specimens become twisted, and lose all similarity to the corresponding organs in all other Coleoptera. The tarsi are not heteromerous, but consist of two or four joints, and are destitute of claws. Such a combination of characters is not met with in any other group of insects, and lends justification to those entomologists who have treated the Stylopidæ as a separate order. There is no part of their structure, however, which can be considered as quite incompatible with the Coleopterous type, except the extremely short prothorax, and the intimate connection of this segment with the middle thorax.



STYLOPS SPENCEI.

The early stages and mode of development of the Stylopidæ are not essentially different from those of the Meloïdæ and Cantharidinæ, already described. But the females are viviparous, the eggs hatching within their bodies, and the young crawl forth from an orifice situated in the part of the body of the parent which projects from the abdomen of the Bee. One female gives birth to many thousands of these tiny larvæ, which are moderately active hexapods, and resemble the first stage of the larvæ of Sitaris. They crawl forth and attach themselves to the hairs of other Bees, and are by them carried to their cells, where they penetrate the bodies of the Bee-grubs and feed on their substance, undergoing changes not very dissimilar to those of the Meloïdæ, the larvæ in their second stage being footless and blind; they continue to live in the interior of the Bee without destroying its life, or hindering it in its growth from the larva state to the chrysalis and adult Bee, only in their later stages protruding the anterior part of their bodies between the abdominal segments of the Bee. The female Stylops stops in its development at this stage; the male emerges from its pupa skin in the winged form we have already described.

Such in brief *resumé* is the life-history of these extraordinary little insects. According to an exhaustive monograph published by Sir Sidney Saunders in 1872, the diversity both of structure and habits among the species composing the group is much greater than was until quite recently supposed. One of them, which inhabits Ceylon, is parasitic on the workers of an Ant, and many species prey

upon Wasps, both of the social and the solitary genera; but the most aberrant of all the Stylopidæ is a kind which has been found in the abdomen of an insect of the order Homoptera, from Borneo. Eight species are found in England.

SECTION TETRAMERA.

We now arrive at the third great section of the order Coleoptera, distinguished from all others by the atrophy of the fourth tarsal joint in all the feet, by which these members have only four freely-articulating joints. The atrophied joint is in most cases extremely minute, and concealed in the deep notch of the third joint, which latter is in the vast majority of the species bi-lobed, and clothed beneath with a brush of minute hairs. The section is nearly equal to the Pentamera in the number of its described species, and forms more than a third of the total contents of the order. All the species are vegetable feeders.

FAMILY CURCULIONIDÆ.

The Curculionidæ, or Weevils, are recognisable by the head being prolonged into a rostrum, or "snout," which bears at its extremity the organs of the mouth. With the exception of the upper lip, all the buccal organs are complete, and exhibit a high degree of development or specialisation, the ligula, or tongue, being in a portion of the family concealed by the mentum. The antennæ are nearly always terminated by a club, and in the most numerous subdivisions are geniculate, or elbowed, the first joint or scape being proportionally very long, and the remainder, or flagellum, being set on at an angle to it: the joints between the scape and the club, which are often gradually thickened, are called together the "funiculum." The abdomen is composed of five, rarely of six segments, and the pronotum, or dorsal plate of the prothorax, is blended with the side pieces of the pectoral segment.

Weevils are among the commonest of all Beetles in temperate as well as tropical countries. About 12,000 species have been described, but it has been computed by a learned student of the family that not fewer than 30,000 exist in nature. They attack, principally in their larva stage, every part of vegetable tissues, and all forms of plant life, from cryptogams and the tenderest shrubs to the largest forest-tree: buds, leaves, flowers, fruits, seeds, nuts, stem, bark, wood, pith, and roots are all equally their prey, the species very generally confining themselves to their own special variety of food, and many restricting themselves to one kind of plant, a habit which partly accounts for their vast numbers; for owing to this and their varied tastes, a score or more of distinct species are accommodated by a single species of tree, and are adapted in structure and habits to the limited conditions prescribed by such a mode of life. The adult Beetles are not in themselves, as a rule, injurious, but the larvæ, in very many cases, are very destructive, not only to forests and orchards, but to seeds and cereals stored in warehouses. They are footless, cylindrical grubs, somewhat narrowed and curved behind, and of rather firm integuments, and are distinguishable from the similar grubs of Lamellicorns, besides the absence of feet, by their atrophied antennæ. Some few species, leaf-miners, have straight bodies, and the larvæ of the Calandra group, so destructive to grain and to sugar and palm-tree plantations in the tropics, differ in being flexuous instead of simply curved towards the tail. Most of them pass their transformations within the vegetable substance which serves as their pabulum, constructing a sort of cocoon; but some crawl forth and bury themselves in the soil before changing to the pupa state.

The classification of the vast multitude of forms constituting this important family has been found a most difficult problem, and within the past twenty years it has been remodelled from its foundations several times by entomologists who have made the subject their study. Previous to that time, the obvious division into Weevils with straight antennæ (Orthocera) and Weevils with geniculated antennæ (Gonatocera) was the prevailing system, the second or larger division being again subdivided, according to the length of the rostrum. This classification was overthrown by the celebrated systematist, Lacordaire, on the ground of its violating the really natural affinities of the forms, and he divided the whole family into "legions," according to modifications in the structure of the minute parts of the mouth. Still more recently, Dr. Leconte, of Philadelphia, in a learned monograph on the Curculionidæ of the United States, has proposed an entirely different system, grouping the family primarily according to sexual differences in the abdomen, and the presence or absence of a lateral fold on the inner surface of the wing-cases. Under these chief

divisions are comprised a large number of sub-families, into which our space does not admit of our entering, and we must confine ourselves to a brief mention of some of the most interesting species.

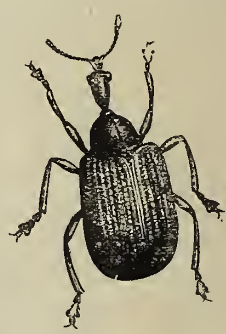
One of the most important of the sub-families, in its relations to man, are the Calandrinæ, or Weevils proper, which include the *Calandra granaria*, a small species, well known throughout Europe for the devastation it causes in granaries, the females, in the usual manner of Curculionidæ,

RHYNCHOPHORUS PALMARUM.

laying their minute eggs in little holes previously nibbled by them in grains of corn ; the grub, which soon hatches, rapidly devours the contents, without affecting the whole appearance of the grain, and undergoing inside its transformation, emerges as a winged Beetle in forty or fifty days after the laying of the egg. Many generations succeed each other during the warmer months of the year, and the Beetle thus multiplies indefinitely. An allied species (*Calandra oryzæ*), causes similar injury to stores of rice and maize in India and other tropical regions. These are the *minims* of the sub-family ; others belonging to the genera *Rhyncophorus* and *Macrochirus* reach a

great size, and are among the largest Beetles known. These are not granivorous, but live in the stems of succulent plants and trees, especially palms and bananas, several kinds being very destructive also to the sugar-cane. The fat grubs of a species of *Rhyncophorus*, found in sugar-plantations in Guiana, contain in their entrails lumps of sweet wax, secreted from their saccharine pabulum, and are boiled and eaten by the natives. We figure a species of this genus, with its obese larva *in situ*. The species of the brilliant metallic-coloured genus *Rhynchites*, belonging to the old section *Orthocera*, attack various fruits. Many species are common in Europe, and seventeen are inhabitants of the British Islands. The females lay their eggs in the newly-formed fruit of apples, pears, plums, &c., piercing first holes for the purpose, and afterwards notching the peduncle of the fruit, so that it soon dies and falls. *Rhynchites bacchus*, a species of a rich golden-purple hue, and a quarter of an inch in length, sometimes proves very destructive to the pear crop in France. *Apoderus coryli* attacks nuts, and is common on hazel-trees in woods in England. The allied genus *Apion*, small blue-black Weevils, with pear-shaped bodies, prey upon the seeds of leguminous shrubs, especially vetches, and are of great number and variety. The species belonging to the genus *Larinus* affect plants of the *Compositæ* order, the larvæ feeding on the flowers, forming little cocoons by gluing together fibrils and fragments of the inflorescence. A large number of Curculionidæ pass their early stages in the pith of stems of trees and plants. One small group (*Orchestes*), remarkable for their thickened hind legs and faculty of leaping, are leaf-miners in their larva state; as many as ten or twelve of the larvæ of *Orchestes pratensis* have been seen in discoloured patches on the leaves of *Centaurea scabiosa*.


RHYNCHITES BACCHUS.


APODERUS CORYLI.

FAMILY SCOLYTIDÆ.

The Scolytidæ are pre-eminently wood-borers, consisting of small cylindrical or oblong-oval Beetles, well fitted for their functions by their short, strong-toothed mandibles, flattened and dentate anterior legs, and the grater-like surface of their prothorax. Many of their species attract attention by the curious vermiform, branched, and radiating galleries which they sculpture in the inner bark and adjoining hard wood of trees in our parks and avenues. They are effectively distinguished from the Curculionidæ by their linear naked tarsi, and very short and broad muzzle. The result of their labours is to destroy the bark, whereby the trees themselves are rendered easy prey to internal wood-borers. The destruction caused by the numerous species in the royal or national forests of France and Germany has led to their habits being closely studied on the Continent by many eminent observers, and recorded in voluminous treatises.

In our own country much curious and original information regarding our native species has been furnished by Dr. Algernon Chapman. A peculiar feature in their habits is the co-operation which has been observed between the sexes—the adult insects—in the work of wood-burrowing; and another is the performance of the functions of pairing and ovipositing, like the transformations—at least, in some of the species—within the burrows. This latter, however, is not continued, as may well be imagined, from generation to generation, such breeding in-and-in being abhorrent to nature, judging from the various ways in which it is guarded against throughout both the animal and vegetable creations; orifices of exit from the galleries, therefore, always exist, by which the winged adults are free to go forth and pair with members of other colonies. The trees preferred by the Scolytidæ are elms, ash, oak, poplar, and various coniferæ and fruit-trees; and when they have secured undisturbed occupation, they have been known in a short time seriously to thin whole forests. The greater number of the species affect the inner bark, or cambium layer, of the trees, the work commencing by the parent insect burrowing a gallery, along the sides of which she lays her eggs, the larvæ on being hatched forming their burrows at right angles to that of the parent, and which burrows diverge as the grub increases in size, so that in time they assume that fan-like appearance which is so commonly seen. *Hylesinus raxini*, the common burrower of the ash-tree in England, is stated by Dr. Chapman to prefer recently-fallen timber to the living tree; and in the first attack the female commences the burrow, the male not beginning until she has quite buried herself within. In the course of a few days, however, both

are busily at work, extending the gallery in both directions close to the hard wood, and scooping a surface-groove upon it. In the course of time, and after the deposition of eggs, from fifteen to one hundred in each burrow, the original female, and often the male, dies, their dead bodies remaining in the galleries for years afterwards; but the perfect insects of the new generation, which emerge from the pupæ at the ends of the larval burrows in the autumn of the year in which they were first hatched, gnaw a channel of exit, in the following spring, to the surface of the tree, and fly away. *H. crenatus*, a larger species, affecting also the ash, prefers living trees, and takes two years to complete its transformations. Another species, *Cryphalus binodulus*, attacks the aspen, utterly destroying the tree, beginning with the branches and working downwards; and *Scolytus destructor*, also common in England, the elm, destroying not only the inner bark, but burrowing half an inch deep into the solid wood. The numerous species of the genus *Platypus*, and its allies, differ in habits in some particulars from the rest of the family; at least, our English species, *P. cylindrus*, is found to burrow in the solid wood of oaks and beeches.

LARINUS MACULOSUS.

The other families of the Rhynchophora are the BRENTHIDÆ, ANTHRIBIDÆ, and BRUCHIDÆ. The first-mentioned are very elongate, narrow Beetles, with rostrum long and filiform in the females, and shorter and broader in the males, the latter sex being provided also with strong mandibles. Like the Curculionidæ, they have no labrum, or upper lip. They are bark-insects, very numerous and varied in the tropics, and displaying great eccentricities of form, but extremely rare in north temperate

latitudes, one species only occurring in Europe, in the maritime districts of the Mediterranean. The ANTHRIBIDÆ have a short and robust rostrum, and long, slender antennæ, terminated by a club of from three to five joints. They are clothed with fine pubescence, variegated with various shades of brown and grey. They differ from Curculionidæ by the presence of an upper lip. They are lignivorous, with the exception of a limited number, which live on woody boleti on trees. The BRUCHIDÆ are insects of short and broad forms, remarkable for the thickened hind thighs and the inclined head, furnished with a short snout. They are pre-eminently granivorous insects, all the species whose habits are known living—at least, in their larval stage—in seeds. A large number infest cultivated kinds of peas and beans, one (*Bruchus pisi*), being a well-known pest in granaries; its larvæ are so numerous in some years in Germany as to destroy thirty per cent. of the pea crop. The tropical species of the genus *Caryoborus* prefers the nuts of palm-trees, some of which, of stone-like hardness, are not proof against their short, but strong, curved mandibles. Fourteen species of the family are found in Britain. By the structure of their buccal organs they seem to form a connecting link between the Rhyncophora and the other two great divisions of the section Tetramera, the LONGICORNIA and the PHYTOPHAGA.

TRIBE LONGICORNIA.

The numerous tribe of Longicorns, or "long horns"—so called from the great length of antennæ which distinguishes the majority of its constituents—comprises a vast variety of generic and specific forms, conspicuous for the grace and beauty of their outlines and the elegance of their colours and markings, qualities which have rendered them great favourites with collectors. In size they rarely fall below the average dimensions of Coleopterous insects, whilst many of them reach a gigantic length, *Titanus gigas*, of Cayenne and the Amazons, and *Xixuthrus heros*, of the Fiji Islands, reaching half a foot in length, and being amongst the largest of known Beetles. The antennæ, though normally composed of long cylindrical joints, are subject to great diversity in length, shape, and ornamentation, and vary in important details of structure. The usual number of joints is often departed from, species occurring with as many as twenty, and in form they exhibit an endless variety; the joints, generally simple and linear, becoming furrowed or spined on one or both sides, or assuming, some of them a clavate, ovate, or even bulbous form, or branching laterally, giving to the organs a saw-like, pectinate, or fan-like appearance, or, again, presenting ornamental tufts of hair tinted with contrasted colours. The general Longicorn type is, however, preserved amidst all these and other variations.

Like the rest of the Tetramera, the Longicornia are exclusively vegetable feeders, but they are less varied in their food and habits than the Rhyncophora. The perfect insects are met with on the trunks or branches of trees, gnawing the wood or bark, or imbibing sweet sap exuding from wounds in the trees, on leaves and flowers. The larvæ resemble in form those of the Buprestidæ before described, having a dilated prothorax; they are fleshy grubs, provided with three pairs of minute feet, often quite rudimentary, and well-developed maxillary and labial palpi. They live, according to their species, either under the bark of trees or in the interior of the wood, some feeding on roots, but none are known to attack fruit or seeds. Some, however, are often very injurious to fruit-trees, as, for instance, the "apple-tree borer" of the United States, a species of *Saperda*, the larva of which, emerging from an egg laid by the parent insect in the bark, eats its way through to the sap-wood of the tree, where it feeds up, and when half grown farther penetrates to the heart of the tree, living for three years in this stage, and when ready to undergo its transformations returning towards the surface, and passing into the pupa state in a little cell which it forms under the bark. In forest countries, whenever a dead tree is met with, the heart-wood is sure to be found infested with species of Longicornia, often in both the larval and adult conditions. It is thus that many of the large species belonging to the *Prioninæ* sub-family are found. In the pine-woods of North America two large species of this group are found in this way, viz., *Orthosoma cylindricum* and *Prionus brevicornis*, the latter of which, like many other insects, has transferred its attentions from indigenous species of trees to the introduced fruit-trees of the orchard, destroying plum and pear-trees and the grape-vine. Upwards of 8,000 species of Longicornia are at present known to science, the forest regions within and near the tropics, as may be supposed, yielding by far the greatest number. Fifty-five only inhabit the British Islands, and the whole of Europe contains only about 500. Notwithstanding the great diversity of their structure, they form but one natural family, the CERAMBYCIDÆ. This

59 THE STAG-HORNED LONGICORN (*Acanthophorus serraticornis*).

is divisible into three sub-families, founded on structural characters, which, though not very sharply defined, form assemblages of genera agreeing in general appearance.

The first, or the *Prioninæ*, are distinguished by the pronotum, or dorsal surface of the prothorax, being separated from the flanks by a sharp edge, and also by the haunches of the anterior pair of legs being elongate and transverse, and lying in similar transverse sockets. The eyes are very generally entire, that is, not notched in front, to make room for the play of the basal joint of the antennæ; but this character is exhibited by many members of the next sub-family. Most of the large and bulky Longicorns with short antennæ belong to the *Prioninæ*. A large number are nocturnal in their habits, and are rarely seen except when flying abroad on sultry evenings, or when the tree-trunks containing them are cleft by the axe of the wood-cutter. These are characterised by the coarseness of the facets into which their eyes are divided, a feature which seems to be associated in some groups of Coleoptera with nocturnal vision. The few species of the sub-family inhabiting north temperate climates belong to this division, such as those constituting the genus *Prionus*, one of which (*P. coriarius*) is found not uncommonly in the southern counties of England, flying abroad in the summer evenings, or seen imbibing the sap from the trunks of old oak-trees in parks. A series of magnificent species of glittering metallic colours, constituting the genus *Psalidognathus*, inhabits exclusively the valleys of the Andes, from South Peru to the Isthmus of Panama. Like several other tropical genera, these are furnished, especially in the male sex, with long toothed mandibles, and present a certain resemblance to the true Stag-beetles, from which, however, they are readily distinguished by their four-jointed tarsi. *Acanthophorus serraticornis*, one of these forms, of very large size, is an inhabitant of Southern India. The most wonderful insect of this group, however, is *Colpoderus forcipatus*, a species discovered by Dr. Pogge in the country of the Muata Yanvo in Central Africa, which is armed with mandibles of excessive length, bent at the middle at a right angle, and each blade strongly forked at the tip. Another section of *Prioninæ* have eyes divided into fine facets, and these are diurnal in their habits. Most of them inhabit tropical America, and are of varied and often metallic coloration. The genus *Mallaspis*, belonging to this section, presents curious modifications in the form of the antennæ, some of the joints being flattened into thin plates and having a metallic lustre.

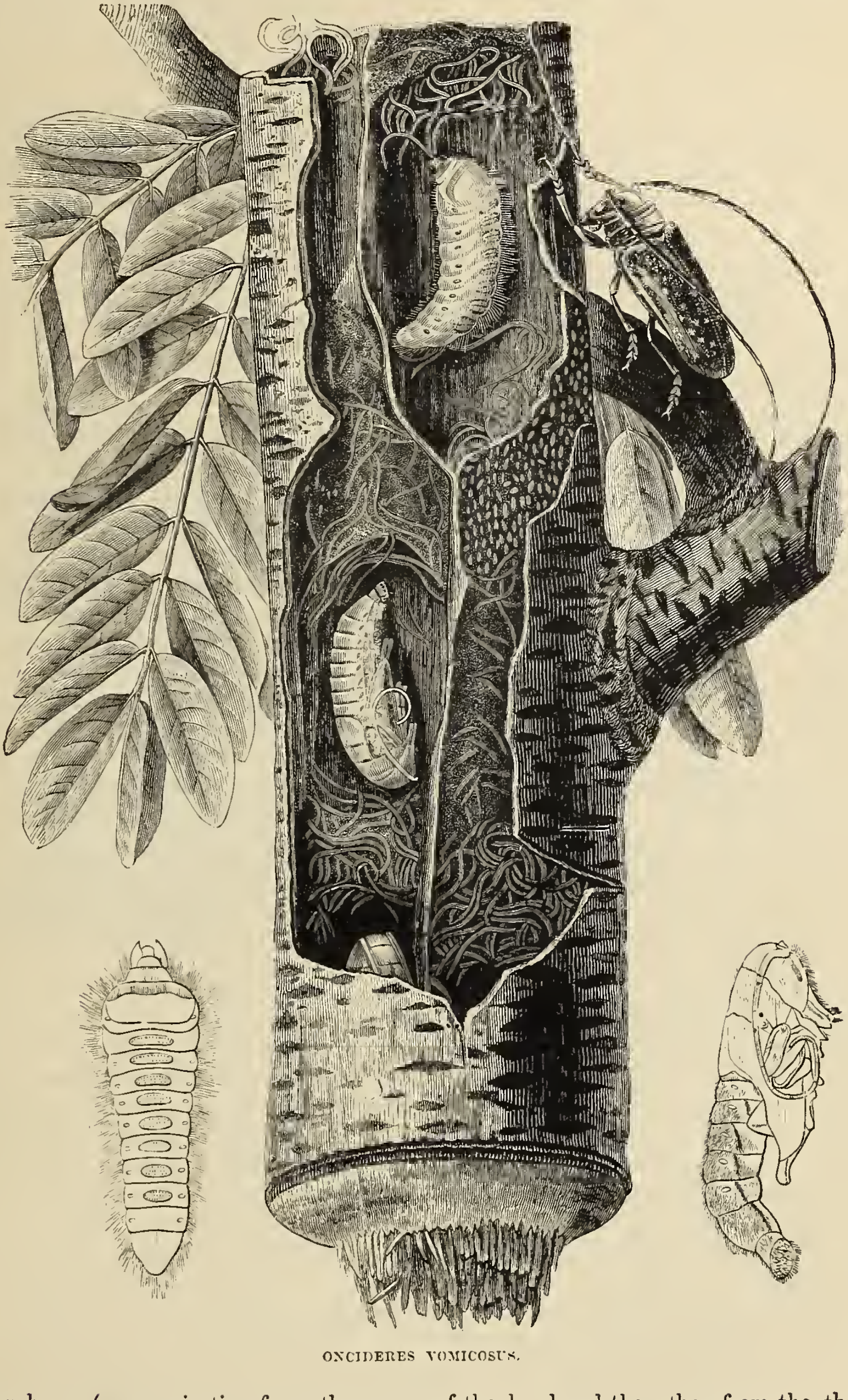
The second sub-family, called *Cerambycinæ*, differ from the *Prioninæ* in the contraction of the sockets of the anterior haunches, the latter being either rounded, or conical and projecting from the sockets, and in the flanks of the prothorax being continuous with the dorsal surface or pronotum. Like the preceding sub-family, they form two natural groups, one nocturnal, with coarsely faceted eyes, and one diurnal, with the same organs smooth and minutely divided. The nocturnal series are usually of dull brown or blackish colours, but the day-fliers are of bright hues, very often brilliantly metallic, and endlessly diversified in the markings with which they are variegated. The variety of colours and patterns is not irregular or capricious, but observes a sort of law, a genus or group of genera having one common type, which is modified, often in a most elegant and artistic manner, in each species. Such is the numerous genus *Clytus*, slender Wasp-like Longicorns, of which we have several species in England, found on flowers and newly-felled timber. Such also are the *Lepturæ*, a group distinguished by the head being constricted behind into a neck, the species of which, inhabiting chiefly temperate or even high northern latitudes and Alpine regions, are found on flowers. A large proportion of our native British Longicorns belongs to the *Leptura* group, and many may be met with on umbelliferous and composite flowers and wild roses in early summer. *Leptura aurulenta* and *quadrifasciata*, found in the New Forest, are elegant insects of silky dark brown hue, with bands of golden-yellow on the wing-covers.

Amid the great diversity of forms for which this group of Cerambycidæ is remarkable are the genera which mimic Bees, Wasps, and other Hymenoptera. They chiefly frequent tropical America and Australia, and are found on flowers, or flying about tree-trunks, in the same situations as the insects whose forms and colours they have unconsciously been brought to assume, by way of disguise and protection. As a rule, their wing-covers are much shortened, sometimes becoming mere square plates, covering the base of the abdomen, as in the Staphylinidæ: this, apparently, in order to leave the membranous wings exposed, and give them freer play. In some of the species, as *Sphecomorpha chalybea*, *Odontocera fasciata*, *Tomopterus larroïdes*, and others, the abdomen at the base is constricted

into a narrow waist, like the Wasps, thus rendering still more exact their resemblance to the smaller solitary species of that family, to which they are also similar in their light brown and yellow-banded style of colours and markings. Others, in order to resemble deceptively little Bees, have tufts of hairs on their hind shanks, representing the dilated pollen-gathering tibiæ of the Bees. These extraordinary little creatures are usually rare in the countries where they are found, and although the species are very numerous, they are not common in collections, and are consequently but little known. Another and very differently coloured set of forms are the *Callichromæ*—Longicorns of large size, and long and graceful forms, coloured golden-green, blue, purple, and violet, furnished with very long antennæ, and much lengthened hind legs, the shanks of which, in some species, have leaf-like expansions. To this group, distributed in many scores of species over the warmer countries of the earth, our well-known British Musk-beetle (*Aromia moschata*) belongs. The early stages of this insect are passed in the trunks and stems of willows, and the perfect insect is common in most parts of England on young willow-branches in osier-beds. It emits a strong odour, slightly musky, of attar of roses, a property which is common to the whole group to which it belongs, and which is much more powerful in some of the exotic species. The volatile secretion producing the smell is emitted by two glands situated in the metathorax of the insect.

The third and last sub-family, the *Lamiinæ*, more numerous, though not more varied, than the *Cerambycinæ*, are almost exclusively confined, in the adult stage, to the branches and trunks of trees, rarely being found on foliage, and never on flowers. In gnawing the bark or wood as food, or in preparing a nidus for the deposition of eggs, they cling to the surface with their generally powerful legs and claws, and their mouths being thus brought into contact with the wood, they ply their mandibles with great ease and precision. In accordance with this habit, their foreheads are vertical and usually at right angles with the longitudinal axis of the body, which is never quite the case with the other sub-families of Longicorns. To this, however, there are exceptions in the numerous remarkable Australasian group of *Tmesisterni*, which, although belonging to the *Lamiinæ*, have oblique foreheads like the *Cerambycinæ;* a more constant character is therefore used to distinguish the sub-family, viz., the existence of an oblique groove on the inner side of the anterior tibiæ, which is observable in every species without exception. The prevailing livery of the Lamiinæ is a clothing of fine adpressed hairs, coloured in a variegated pattern to resemble bark or wood. In a large number of species the resemblance of the insect in colour and markings to the bark of the particular tree on which it lives is most exact. Such is the case with the Brazilian *Onychocerus scorpio*, and the numerous species of *Acanthoderes*, *Oreodera*, and many others. The huge *Omacantha gigas*, a native of the Gold Coast of Western Africa, resembles a branch with a patch of dark mould on each side. Several genera are composed of long and slender species, having all a streaked patch, of a different colour from the rest of the body, at their tails, so that they imitate with curious exactitude broken twigs, the coloured tip of the body resembling a section of the wood. Some of the genera, however, consist of insects of a brighter style of coloration and markings, and a few shine with metallic lustre. The larger and handsomer species are found chiefly in tropical Africa, and in the Indian and Malayan regions. The last-named zoological province furnishes the gigantic *Batoceræ*, some of which have robust antennæ, nearly a foot in length, and armed with briar-like spines; and in Northern India and Assam occur the *Aristobiæ*, with tesselated orange and black colours and elegantly tufted antennæ. The Mediterranean region furnishes a numerous wingless group (Dorcadion), found only on the ground amongst herbage, the larvæ feeding on roots. In the forests of North and South America a set of species are found, of nearly cylindrical form, which have the singular habit of gnawing branches of trees all round, to a depth sufficient to cause the bough to break and fall to the ground. These form the genus *Oncideres*, belonging to a numerous group distinguished by their elongated forms, strong and frequently bowed legs, and powerful claws adapted for grasping. The insect selects a branch or bough suitable for its purpose, and, embracing it tightly, proceeds to gnaw the bark and wood transversely, and so effective a workman is he that the ring-like notch when finished is as true as if turned in a lathe. The object of this singular trait of industry is in all probability to provide a supply of dead wood for the nourishment of the future progeny. Branches thus neatly sawn off are frequently met with in tropical American woods, and are the objects of wonder to the negroes and creoles, who erroneously suppose them to be the work of *horned*

Dynastidæ, or (in some districts) Stag-beetles. They say the large, heavy-bodied Beetle—in the West Indies the Elephant-beetle (Dynastes Hercules) is the supposed operator—seizes the branch between



ONCIDERES VOMICOSUS.

its two long horns (one projecting from the crown of the head and the other from the thorax), and setting itself in rapid rotatory motion, continues until the branch is sawn through. But the horns or jaws of these large Beetles are quite incapable of the work thus attributed to them; and, in fact, the

story is a pure myth. The point has been settled by direct observation. A not uncommon North American species (*Oncideres cingulatus*), called the "Hickory girdler," is known to saw branches of the hickory-tree (*Carya alba*) in the manner we have described, and its habits have been carefully studied by Professor Haldeman. Our figure represents a larger species (*Oncideres vomicosus*) not uncommon in Brazil.

TRIBE PHYTOPHAGA.

The Phytophaga, the third and last tribe of the great Tetramerous division, are, as a rule, distinguishable from the Longicornia (with which they agree in the absence of the snout-like prolongation of the head which characterises the Rhyncophora) by the shorter body and antennæ, and the brightly-coloured and polished integuments. In habits they differ by living only on the foliage of plants, not on the wood or fruit; and they are, with the exception of one genus (*Cyrtonus*), diurnal in their period of activity, having in consequence finely-faceted eyes. So close, however, is their relationship to the Longicornia, that there is no single structural character to be pointed out as applicable in all cases for distinguishing the two tribes. In nearly all the species the tarsi are short and broad, with the third joint bi-lobed or heart-shaped, and the rudimentary or functionless fourth joint always visible at the base of the claw-joint; beneath, the joints 1—3 are furnished with flat brush-like palms, which enable the insects to walk with ease, even back downward, on the under surface of leaves; and the claws are very often adapted for clinging to the edges of foliage, either by their position, or by being more or less toothed on their inner sides.

Although so closely allied in structure in the adult form, the Longicorns and the Phytophaga are strongly contrasted in their larva stage. The larvæ of the Phytophaga are nearly always of short and convex form of body, rarely sub-cylindrical or depressed, and of firm leathery texture, sometimes metallic-coloured like the perfect insects. Their abdominal segments are frequently provided with fleshy or scaly tubercles, or spines and bristles, and the anal one is prolonged beneath into a retractile tube, which is used in walking. In all cases they live on the same food, and generally on the same species of tree or shrub, as the perfect insect. On the same plant the eggs are laid, and in numerous cases, where the species infest cultivated grounds, their great and rapid multiplication during the summer months renders them the most injurious of all insect pests to the farmer and gardener. The famous Colorado Potato-beetle, which increased so suddenly, and created such devastation in the United States about ten years ago, and seemed likely to cross the Atlantic, to the alarm of the agriculturists of Western Europe, belongs to the family, as does also the "Turnip-jack," the plague of the British farmer. One numerous class of the larvæ (belonging to the Hispinæ and Halticinæ sub-families) are miners, *i.e.*, they live within the cuticles of leaves, devouring the parenchyma, and undergoing their transformations in the same confined space. Another large group (belonging to the sub-families *Criocerinæ* and *Cassidinæ*) live exposed on leaves, and have the remarkable habit of concealing themselves with their own excrement, which is retained and secured by a special horny apparatus at the end of their bodies. In the typical groups of *Chrysomelinæ* and *Eumolpinæ*, the larvæ feed at large on plants, and bury themselves in the earth previous to changing into the pupa stage.

The Phytophaga are divided into four sections, which are nearly equivalent to the families of other tribes. The first of these, the Eupoda, approach nearest in their general form, as well as in their structural characters, to the Longicornia and the family Bruchidæ of the Rhyncophora. Among them are the large brilliantly-metallic *Sagræ*, or Kangaroo-beetles of tropical Asia and Africa, remarkable for their greatly-enlarged hind legs; the *Donaciæ*, elegant insects of similar form, but smaller and of less brilliant colours, which live on water-lilies and other aquatic plants chiefly in north temperate climates, nineteen species being found in the British Islands. They pass their early stages among the roots of the same plants; and the *Criocerinæ*, of which we have several British species—the principal being *Crioceris merdigera*, of uniform brownish tint—parasitic on lilies, and the prettily-spotted *C. asparagi*, found abundantly on asparagus plants in the south of England. The second section are the Camptosomæ, characterised by the strong curvature of the ventral segments of the abdomen, by which the three middle ones are much contracted. To this belongs a large series of genera, having usually a compact oval or oblong form of body, and extremely varied colours, polished metallic coloration being less the rule than buff, yellow, and red, spotted or striped with darker hues. The British species best known of this section are the *Clythra tridentata* and

quadripunctata found in oak and hazel woods, and the brilliant golden-green *Cryptocephali*, common on flowers of hawkweed on dry banks in the month of June. The third section are the CYCLICA, and consist of those genera in which the abdominal segments are of normal proportions, and the antennæ are filiform. The typical genus is *Chrysomela*, which, with its various closely-allied sub-genera, is distributed in many hundreds of species over all the temperate and tropical parts of the earth. Its species, as a rule, are of polished metallic colours, some, like the *C. cerealis*, a British species found on Snowdon, of golden or brassy-green ground colour, with rich purple stripes; others equally brilliant, but of more uniform metallic hues, such as *C. menthastri*, a large brassy-green kind, found on aquatic plants, *C. polita* and *C. stavhylea*, abundant on nettles in spring, and the bronzed and punctured *C. Banksii*, met with on sandy banks on our southern coasts. *Lina populi*,

CRIOCERIS MERDIGERA.

closely allied to the true Chrysomelæ, is a well-known British species, found on poplars. As is the rule with the Phytophaga of our northern climates, a few individuals of the late summer brood of these *Chrysomelæ* pass the winter in the adult stage in a dormant state in moss, becoming the parents of the spring broods in the following year.

The sub-family *Chrysomelinæ*, to which the above-mentioned species belong, contains most of the large and conspicuous insects of the section; but it is far exceeded in the number of its genera and species by the *Galerucinæ*, a sub-family which includes all the *Halticides*, or jumping *Phytophaga*, insects usually of very small size, and almost infinite in their numbers and diversity. The *Galerucinæ* may be readily distinguished from the *Chrysomelinæ* by the antennæ being inserted near together in the middle of the forehead, these organs in the *Chrysomelinæ* being situated near the inner margin of the eyes, and therefore widely distant from each other. The *ambulatorial Galerucinæ* are, as a rule, of larger size than the *saltatorial* division of the sub-family (the *Halticides*), and are insects of rather slow movements. Many species occur in the British Islands; some (*Galeruca tanaceti*, *capreæ*, and *halensis*) are met with abundantly on heaths and uncultivated grassy hills and slopes, crawling over the low herbage; others are found only on trees. The *Halticides*, as we have already stated, are—at least, partly—leaf-miners in their early stages, and include the Turnip-fly (*Phyllotreta nemorum*), and many

other allied species destructive to cruciferous plants. In temperate latitudes none but species of small and even minute size are met with, the latter resembling fleas in their dimensions and great agility in leaping; but in the tropics much larger and more brightly-coloured and variegated forms swarm on bushes and herbaceous vegetation. The fourth and last section are the CRYPTOSTOMÆ, distinguished by the forehead being inflected downwards, bringing the mouth (which is much reduced in all its dimensions) to the under surface of the head, and also by the claw-joint of the tarsi scarcely projecting beyond the lobes of the third joint. The antennæ are short, and very often straight and rigid. To this section belong two sub-families, *Hispinæ* and *Cassidinæ*, which run into eccentric and striking forms, the thorax and elytra of the *Hispinæ*, in their extreme developments, being studded with spines, and the same parts in the *Cassidinæ* being laterally expanded, so as to cover the head and trunk as

LINA POPULI.

with a rounded shield. These extreme forms are placed naturally by all entomologists who have classified the groups at the end of the two respective sub-families, so that the classification in each begins with species which partake of the characters of both, and is carried on through the very numerous genera and species, pretty gradually receding on each hand from the common type. Thirteen species of the genus *Cassida* are met with in England, two of which are not uncommon on thistles in summer, on which plants the curious habits of the larvæ may be studied, protected as they feed by a little mass of their own excrement, secured by a horny forked process at their tails. Some of our native species of Cassida are ornamented with bright silvery streaks or markings, which, however, give but a faint idea of the extreme brilliancy of many tropical ones, some of which resemble beads of polished gold or silver, and others, of more pearly lustre, glitter on the leaves like drops of dew in the morning sun.

TRIBE EROTYLIDES.

This group differs from the preceding in many important characters, and belongs but imperfectly to the Tetramera section, many of its genera having a conspicuous fourth joint to the tarsi, and the antennæ being terminated by a distinct club, as in the more typical genera of the Clavicornia tribe. All the species, upwards of 1,000 in number, live on fungi or boleti, and have smooth integu-

ments and bright colours, in which red, yellow, and black hues prevail, forming often elegant patterns on the wing-covers. The larvæ are elongated, of leathery texture, slightly narrowed at the two extremities, the head furnished with three-jointed antennæ and ocelli on each side, and the thorax with three pairs of feet of normal development. In their structure they point to a relationship with the family Coccinellidæ. The transformations of the larger exotic species are up to the present unrecorded; but the *Erotylus Hopei*, which the present writer had the opportunity of observing in South America, seems to differ a little from the European species (genus Triplax), in being studded with longish spines, and the anal segment furnished with a pair of very long setiform appendages. The prothoracic segment is larger than the others, and nearly semicircular. These larvæ were found abundantly on hard boleti on an old stump, and underwent their transformations attached by the tail to leaves, precisely like the Lady-birds (Coccinellæ). The tribe is generally considered as a natural family, and is divided into three sub-families: *Languriinæ* (extremely narrow and elongate forms, with broadly dilated tarsi, of which there are no European species), *Helotinæ* (handsomely sculptured and metallic species, inhabiting tropical Asia and Africa), and the typical group *Erotylinæ*, comprising the great bulk of the species, and distributed over all temperate and tropical regions. The Erotylinæ of the Old World are of elongated oblong form, but those of America are in great part dilated, ovate, or with elytra expanded and raised into huge dromedary-like bosses.

SECTION TRIMERA.

In this section the tarsi have only three true joints, the joint which is apparently the analogue of the third in the Pentamera being rudimentary at the base of the claw-joint, just as the fourth

COCCINELLA SEPTEMPUNCTATA (SEVEN-SPOTTED LADY-BIRD).

is in the Tetramcra. The section is divided into two families, *Endomychidæ* and *Coccinellidæ*, which each contain only one family.

FAMILY ENDOMYCHIDÆ.

The insects of this family differ from the COCCINELLIDÆ chiefly in their much longer and more robust antennæ, which are generally half the length of the body, never retractile under the head and breast, and terminated by a distinct club of three joints; they are also distinguished by their long legs and by their pronotum being furnished behind with two well-marked grooves. The species live on fungi and boleti, chiefly the smaller growths which affect rotting timber, and reach their greatest development in size, beauty of markings, and strangeness of form in the tropical regions of the eastern hemisphere. About 400 species have been described, two only of which inhabit the British Islands. The larger species, inhabiting India and the islands of the Malayan Archipelago, assume eccentric shapes, the elytra being greatly dilated along the margins and elevated into bosses on the disc, often armed with spines. In many respects these species may be said to represent the similarly-formed *Erotyli* of the same latitudes in the New World. Both perform the same functions in the natural economy of their respective countries; and in each of the two regions the one has been developed apparently at the expense of the other, since none but ordinary forms of Endomychidæ exist in Tropical America, and none but similarly undeveloped forms of Erotylidæ are found in Tropical Asia.

FAMILY COCCINELLIDÆ.

The COCCINELLIDÆ are the familiar insects known under the name of Lady-birds, the great majority of which in all countries have the hemispherical form and prettily-spotted colours that distinguish our common species. Some of the genera, of oblong shape of body, and others, in which the surface is clothed with short hairs, and the colours darker and less varied, may at first sight not be recognisable as belonging to the family; but in such cases they may be known by their three-jointed tarsi, hatchet-shaped terminal joint of the maxillary palpi, and the very short antennæ retractile beneath the prothorax. Nearly the whole family have the peculiar habit of preying on Aphides, or plant-lice, one group only, containing a small number of genera, being leaf-eaters. The larvæ, which are seen in our gardens and fields even more abundantly than the perfect insects, and devour immense quantities of Aphides, are of long oval shape, narrowed behind, with integuments of solid or leathery consistence, and generally dark-coloured; they have six legs, and have considerable freedom and quickness of motion, resembling miniature Lizards somewhat in their gait and attitude; they change into the pupa state on leaves and other objects in the vicinity of Aphis-infested plants, gluing first their tails to the surface. The perfect insect emerges in a few days in the usual way, by a rent in the skin of the pupa, and thus the generations continue whilst the summer lasts. In the late autumn the few surviving adults crawl into sheltered nooks under the loose bark of trees, or in warm mossy banks, and become dormant for the winter. In some summers our common species (*C. septempunctata*) multiplies to a prodigious extent, and the swarms which cover hedges and trees attract the attention of even the most unobservant. The largest swarms on such occasions are to be seen on our southern or eastern coasts, and in some years innumerable individuals have been found drowned on the surface of the sea or cast by the waves on the shore. Upwards of 1,500 species of Coccinellidæ have been described from various parts of the world, of which forty only have been found to occur in the British Islands.

HENRY WALTER BATES

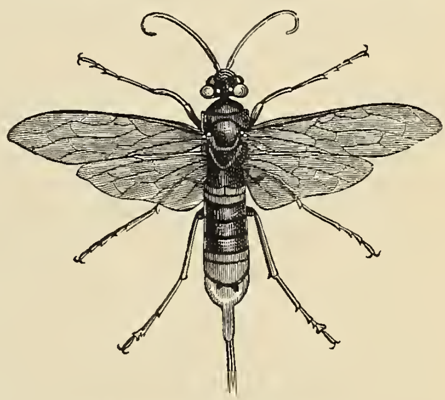
ORDER HYMENOPTERA.

CHAPTER VI

ACULEATA, OR STINGING HYMENOPTERA.

Characters—The Prothorax—The Membranous Wings—The Ovipositor, or "Sting"—Internal Structure—Habits—Larvæ—Intelligence of the Hymenoptera—Their Social Organisation—Workers, or "Neuters"—The Sexes—The Humming of the Bee—Species of Hymenoptera—Fossil Remains—Classification—ACULEATA, OR STINGING HYMENOPTERA—APIARIÆ, or BEES—Characters—THE HIVE BEE—The "Hive"—Arrangement of Cells—Intelligence evinced by the Bees—The Secretion of Wax—Construction of the Cells—Deposition of Eggs—Transformations of the Bee—The Workers—Bees in Winter—The "Royal" Cell—Swarming—Formation of a New Hive—Behaviour of the Young Queen—The Cases of Limited Fertility—HUMBLE BEES—Habits—*Apathus vestalis*—The Solitary Bees—THE VIOLET CARPENTER BEE—Gnawing-out and Excavation of the Nest—THE MASON BEE—Its Cell—The Genus *Osmia*—The Leaf-cutting Bees—The Cuckoo Bees—The *Andrenidæ*—VESPIDÆ, OR WASPS—Characters—Cells—Beauty of Workmanship—Mr. F. Smith's Account of the Founders of a Wasp Colony—Nests of the Common Wasp and of the Hornet—The Nests of other Species—The Solitary Wasps—The Wall Wasp—THE CRABRONIDÆ—The Sand Wasps—THE POMPILIDÆ—THE SAPYGIDÆ—THE MUTILLIDÆ—THE FORMICIDÆ, OR ANTS—Characters—The Nests—The Metamorphosis—The Workers—Milking the Aphides—Charge of the Young—Habits—Intelligence—The Wood Ant—Other Species—THE CHRYSIDIDÆ, OR GOLDEN WASPS.

THE Hymenoptera, which we have placed as the second order of insects with a complete metamorphosis, differ in many important respects from the Coleoptera. Perhaps the most striking external distinction is to be found in the structure of the wings, both pairs of which are membranous, as indicated in the name given to the order by Linnæus, which must be taken to signify "membrane-winged," although, as will be seen hereafter, this texture of the wings is by no means peculiar to the Hymenoptera; and another peculiarity of equal importance, although less immediately obvious, is the condition of the prothorax, which, instead of forming a comparatively large piece, moving freely in front of the other two segments of the thorax, is reduced to a sort of ring, and firmly attached to the succeeding segments, either by a great part of its hinder surface or at least by the upper portion. This reduced prothorax is often called the *collar*, and its condition in the Hymenoptera may be regarded as indicating a certain degree of relationship to the haustellate orders of the Metabola, the Lepidoptera, and Diptera. In the Bees, which belong to the present order, the parts of the mouth undergo modifications tending in a similar direction.



THE TAILED WASP (*Sirex gigas*).

In general, the Hymenoptera may be described as four-winged Flies, having the head very freely attached to the thorax, the prothorax reduced, and attached to the mesothorax as just described; the other two thoracic segments very closely amalgamated (although in one great group this character is not presented); the abdomen ovate, elliptical, or much elongated, composed of segments, the hinder margins of which overlap the base of the succeeding segments, while the lateral margins of the dorsal plates in like manner overlap those of the ventral plates. This arrangement gives great freedom of expansion in respiration, and the movements of the abdomen for the performance of this function are generally more conspicuous in the Hymenoptera than in any other insects. The female is nearly always provided with a sting or an ovipositor issuing from the abdomen.

The head, which is joined to the thorax by a thin neck, bears on its upper surface a pair of antennæ, a pair of compound eyes, usually of considerable size, and sometimes very large, and three simple eyes, or ocelli (*see* Fig. 4, p. 284). Of these organs the antennæ alone need to have a few words said of them. They are frequently long organs, composed of a number of similar joints, and either quite thread-like, or tapering, or clubbed towards the end; but in certain families they consist of a long basal joint (called the *scape*), followed by a comparatively small number of shorter joints, forming a sort of lash, which is generally bent at an angle to the first joint. Such antennæ are called geniculate (*see* Fig. 5, B, p. 284).

Of the parts of the mouth, the mandibles are always freely articulated and adapted for biting purposes, but the other organs may undergo considerable modifications. In general, they present the ordinary structure of the biting mouth, but their articulation is usually very free, enabling them to be

protruded more or less; the lobes of the maxillæ are generally fused together; the mentum is small, and the ligula usually furnished with side lobes (*paraglossæ*). In the Bees, as already noticed (p. 286), the ligula and maxillæ are much elongated to form the proboscis.

The two pairs of membranous wings are attached to the upper part of the sides of the meso- and metathorax, and above the base of each fore wing there is a small movable plate (*tegula*), which is regarded as forming part of the episternum. The surface of the wings is naked or furnished with scattered hairs, and the membrane of which they are composed is usually more or less transparent, although in some cases it may be dark-coloured. In certain forms belonging to the order the wings are altogether absent, or they may be present in one sex and wanting in the other, or, as in the whole tribe of Ants, there may be no wings in the workers (or infertile females), while the perfect males and females possess them; but where they exist the fore wings are almost invariably larger than the posterior pair. All four wings are used in flight; during repose they are generally laid together over the back of the insect; when in action the hind wings are held fast to the fore wings by means of a row of minute hooklets placed along part of their front margin, which cling to a small groove at the posterior edge of the front wings. This mode of union of the wings is characteristic of the Hymenoptera; and many years ago an entomologist maintained that this rather than the membranous texture of the wings, which occurs in other orders of insects, had suggested to Linnæus the name given to the present order, the wings being, as he said, in a manner *married* to each other.

The arrangement of the horny veins (*see* p. 283) which traverse and stiffen these membranous wings is also generally very characteristic. In some few instances they are reduced to a minimum, but in most there run from the base of the fore wings certain longitudinal veins, at first nearly straight, but afterwards more or less bent or waved, and then united by cross-veins in such a manner as to enclose a few angular spaces on the disc of the wing. These spaces are known as *cells*, and their number, arrangement, and form furnish important characters for the classification and description of the Hymenoptera. In the fore wing (*see* figure) we find along the front margin a strong marginal vein (*costa*), with another longitudinal vein parallel and very close to it (the *subcostal vein*), and the two unite beyond the middle of the front margin to form a horny swelling (the *stigma*). From this a small vein generally runs towards the extreme tip of the wing, cutting off a portion of the surface, which is called the *radial cell*, and may be divided into two or more by cross-veins. Another vein, which runs along the middle of the wing from the base, and is continued in a more or less bent or undulated fashion towards the apex of the wing, gives off a branch, which runs up to join the sub-costal vein, and also gives off a branch, the space enclosed between which and the stigma and radial vein is divided by a greater or less number of cross-veins into cells, called the *submarginal cells*. Other cross-veins (known as *recurrent veins*) run back from these cells to the original main vein, enclosing spaces known as *discoidal cells*. The veining of the hind wings is much more simple, and of little or no systematic importance.


DIAGRAM OF HYMENOPTEROUS WING.

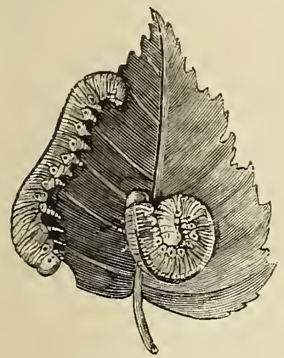
The legs in the Hymenoptera possess great freedom of motion. They are articulated to the thoracic segments by very large, projecting, more or less conical hip-joints (*coxæ*), to which the thighs are attached by means of ring-like trochanters, which, in a great number of the species, are composed of two joints. The tarsi are almost always of five joints, of which the first is generally considerably longer than the rest, and often very different in form.

The number of segments in the abdomen varies considerably, but not more than eight or nine are recognisable, the remainder being either suppressed or concealed within the others. In some forms the abdomen is attached to the thorax by the whole breadth of its base, but in the great majority the first or first and second segments are contracted so as to form a slender stalk, by which the union with the thorax is effected (*see* figure on p. 355). According to some anatomists, the hindmost part of the thoracic mass, which bears a pair of stigmata, does not really belong to the thorax, but constitutes the first segment of the abdomen; this, however, is a question upon which we need not enter. The mode of union of the segments of the abdomen, and the relation of their dorsal and ventral plates, has been already alluded to.

The females of nearly all the species of this order possess organs, either projecting or protrusible

from the apex of the abdomen, which subserve the purpose of conveying the eggs to the spot where their development is to take place, and at the same time, in many instances, constitute formidable offensive weapons. These are the ovipositors, or stings, the parts composing which must be regarded as appendages of the concealed terminal segments of the abdomen. The latter are represented by movable plates, to which the main piece of the protrusible organ is attached, and also furnish sheathing-pieces, often of considerable length, which seem to serve as supports to the latter during the act of penetration. In the great majority of the Hymenoptera the ovipositor, or sting, consists of a single middle principal piece, deeply grooved along its lower surface, and of a pair of slender lancets, which rest against the edges of the middle piece and against each other in the middle line, so as to close up the groove in the single piece, and convert it into a canal. With this canal the oviducts are connected at the base of the organ, so that when its point has been forced a sufficient distance into the proper nidus for the development of the young, the eggs can readily pass to their destination. In the case of those insects in which the organ is converted into a sting, all the parts are exceedingly acute, and the base of the organ is put in communication with a peculiar gland secreting an acrid fluid, which contains much formic acid, and it is the injection of this fluid into the puncture produced by the sting that makes the effects of being stung by a Bee or a Wasp so exceedingly painful. The stings of these animals are not, however, to be regarded as exclusively intended as weapons of war. A very great number of them require to provide their young with a supply of animal food, which consists generally either of the larvæ of other insects or of Spiders. To render these victims helpless and incapable of making their escape, the mother stings them before depositing them with her egg in the nest she has prepared, and by this means they are paralysed, although they can still live for a considerable time. The larva kills them as he wants them, and thus a supply of fresh provisions is secured for him during the whole course of his development. The above may be taken as a general description of the character of the ovipositor in the great majority of the Hymenoptera. It is departed from only in one family, that of the Saw-flies (*Tenthredinidæ*), as will be noticed in the character of that group.


COMMON WASP (*Vespa vulgaris*).


LARVA OF SAW-FLY

Of the internal structure of the Hymenoptera we need not say much, but there are certain peculiarities which should be noticed. The alimentary canal is generally of moderate length; the malpighian vessels are short and numerous; salivary glands, opening into the mouth, occur in most species, and attain a particularly large development in those which have to build cells for the rearing of their larvæ; and the two hinder ganglia of the thorax are united into a single mass, while the ventral chain usually has five or six ganglia. A structural character connected with the great power of flight generally possessed by these insects is the great enlargement of main tracheal stems, which are dilated in the abdomen into very large air-sacs.

In their habits the Hymenoptera are diurnal, most of them flying about actively in the hottest sunshine in search of the flowers upon the sweet juices of which they chiefly live in the perfect state. The working Ants and the females after their nuptial flights, and some few species of other families, are destitute of wings, and can only crawl upon the ground or on plants; but these are active during the day like their more favoured relatives, and the Ants usually retire into their nests and shut themselves up there when night comes on.

In the habits of the larvæ there is great diversity, notwithstanding great general uniformity of structure. Except in one division of the order, the larvæ of these insects are soft, footless creatures, which would be called maggots but for their possessing a hard, horny head. In the Saw-flies and Tailed Wasps, which differ in several important particulars from the rest of the order, the larvæ generally resemble Caterpillars (*see* figure above), possessing three pairs of thoracic limbs, more or less developed; and in the case of the greater number, whose larvæ feed openly upon the leaves of plants, also several pairs of abdominal pro-legs. The maggot-like grubs (*see* figure on p. 356), which always live

in concealment, have nevertheless a great diversity of needs in the matter of food. Some, like the Bees, feed upon the honey and pollen of flowers; the larvæ of the Gall-flies also live upon vegetable food, which is furnished to them by the tissue of the singular excrescences (galls) produced upon trees and plants when punctured by the ovipositors of the parent insects. Of the rest, the larvæ for the most part prefer animal food, at least as a portion of their diet, but the form in which they obtain it differs very considerably. To some nothing seems to come amiss, but the majority are more or less limited as to the kind of food that suits them. The larvæ of other insects and spiders are the chief sources of supply; but the mother may either collect these more or less indiscriminately, or select the individuals of a single species for the maintenance of her progeny. Further, besides all these cases of larvæ residing in cells and fed with various articles collected for them, we find among the Hymenoptera a vast number of examples of parasitism, the females depositing their eggs upon or in the body of some other insect, which then serves as the food of the larvæ. The phenomena of parasitism are here displayed under almost every possible variety of circumstances: the insect attacked may be in any stage of its existence, from the egg to the imago; the parasites may occur singly or several together, and their emergence may take place at very different periods in the life of their victims; but in all cases, except that of the parasites in eggs, their functions would seem to be to allow the host to live and perform its individual part in the world, but to prevent its leaving any progeny behind it. Speaking generally, this would seem to be the most important function of parasitism in nature, and it is shown very strikingly by the internal insect-parasites.

LARVA, NYMPH, AND COCOON OF WOOD ANT (*Natural Size and Magnified*).

The larvæ of the Hymenoptera are provided with silk-glands opening near the mouth, and by means of the secretion produced by these organs they are able to spin a cocoon for their protection during the pupa state. The larvæ generally remain for a considerable time apparently unaltered within the cocoon, and become converted into pupæ only at a period comparatively near that of their emergence as perfect insects. The pupa has all its limbs and other external organs separately encased and quite distinct from each other and from the body (*see* figure above).

The Hymenoptera present the highest development of the mental qualities, whether they are to be regarded as instinctive or as representing absolute intellectual activity, that we meet with anywhere in the class of insects, or indeed among Invertebrate animals in general. It is in providing for the well-being of their progeny more especially that they display these qualities most brilliantly; and although most of their actions in this direction may doubtless be referred to those inherited mental operations which we usually denominate instinct, cases are not wanting in which, in the presence of exceptional circumstances, these little creatures manifestly reason upon the novel position in which they are placed, and adopt such modifications of their ordinary procedure as may be rendered necessary.

These intellectual characteristics, which give the Hymenoptera a pre-eminence over all other insects are specially manifested in connection with another peculiarity, namely, the complex social mode of life of a considerable number of the species. The extraordinary polity of the Bees, Ants, and Wasps, which has excited the wonder and admiration of mankind in all ages, is only partially paralleled elsewhere by the so-called White Ants (Termites), which belong to the Orthopterous order; and although the proceedings of the latter are sufficiently interesting, they yield in many respects to the social Hymenoptera. Fundamentally, the extraordinary social organisation observable in Bees, Ants, and Wasps is connected with the care of the young, an object which appears to exercise a primary influence upon the habits of many other Hymenoptera which do not live in societies. It consists not only in the living together in nests of various construction of a greater or less number of individual insects, all of whom co-operate in carrying on the business of the community, but, further, in the modification of certain individuals to fit them for the performance

of particular offices, so that a society of Hymenoptera is composed of at least three kinds of adult individuals, namely, perfect females, males (whose presence in the nest is only temporary), and workers, or neuters, as they are sometimes called, the last-named having upon their hands the chief part, if not the whole, of the business of the construction and defence of the nest, bringing in supplies of provisions, and rearing the young. The term neuters applied to them is, however, a misnomer; an examination of their anatomy proves them to be imperfectly-developed females, generally quite incapable of producing eggs, and always incapable of being fertilised. Thus these societies are to be regarded as including males for a short time, and at least two kinds of females, namely, true fertile females, whose chief duty is the production of eggs, and infertile females, which take up the other feminine duties of attending to the domestic economy, and especially to the nursing of the young. It is known, chiefly from the study of the Hive Bee, that the eggs laid by the female are of only two kinds, male and female eggs, and that the development of the larvæ from the latter into fertile or infertile females is due to differences in the food administered to them; in fact, when a hive of Bees loses its queen, or fertile female, the surviving workers are able to replace their sovereign by administering the so-called "royal food" to a female larva, which would otherwise have produced a worker, the only condition necessary being that the larva selected for this honour should be very young. Further, it is a well-established fact that occasionally some of the workers—probably owing to their larvæ having accidentally received a portion of "royal food"—acquire a slightly-increased development of the ovaries, and produce eggs, a conclusive proof of their sex.

These facts have been pretty generally known for a great many years, but certain questions arose out of them which were by no means easy to settle, although they may be all referred to the one primary question—at what period is difference of sex established in the progeny of these insects? Does this difference exist already in the egg? or is it set up subsequently by difference of treatment of the larvæ, just as the worker larva may be developed into a queen? This difficult point was settled by the observations of a German pastor, named Dzierzon, who originated a theory, afterwards further developed by the distinguished zoologist, Von Siebold, and now generally accepted, which seems to explain satisfactorily all the phenomena of reproduction as exhibited in Bees.

It has already been stated (p. 294) that in insects the eggs are fertilised during their passage through the oviduct by contact with the male fertilising element, which has been stored up in a special receptacle appended to that passage. Dzierzon found that the eggs laid by very old queens, in which the fertilising element was exhausted, by queens which, from having crippled wings, were unable to take the customary nuptial flight, and by workers which, from their structure, were incapable of being fertilised, always produced males or drones; and hence he inferred that the difference of sex was established at the moment of the deposition of the egg, those eggs destined to produce females or workers being fertilised during their passage through the oviduct, while those which were to furnish males were allowed to pass without fecundation. Subsequent investigations, carried on by Von Siebold, Leuckart, and others, fully confirmed this opinion. Fertilised queens were converted into drone-breeders by exposure to considerable cold, and by the mechanical destruction of the special receptacle above mentioned; and the examination of eggs laid by fertilised queens showed the presence of the fertilising filaments in those intended to produce workers, while no such elements could be detected in those laid in drone-cells. The occurrence of the same phenomena has been demonstrated in the case of other social Hymenopterous insects, and may safely be assumed for all, although of course their demonstration is attended with much greater difficulty in the other species than in the Hive Bee. By what means the female contrives, apparently at will, to fertilise the eggs, or leave them unfecundated, has not yet been ascertained, nor is it very clear how she knows when fertilisation is necessary or unnecessary, except that in the case of the Hive Bee, and perhaps of some Wasps, the different sizes of the cells prepared for rearing males and workers may furnish indications.

Very few of the Hymenoptera seem to possess special arrangements for producing sounds by the friction of one part against another, but many of them, especially Bees and Wasps, produce a humming or buzzing noise, principally during flight. The sound emitted appears to be due to two causes—first, the rapid vibration of the wings in the air, which of course can only be perceived during flight; and, secondly, according to Landois, to the vibration of certain chitinous plates, placed in the orifices

of some of the stigmata, caused by the violent expulsion of the air from the tracheal system. With regard to this second set of sounds, however, a French observer, M. Pérey, comes to a different conclusion, and declares that the removal of the above-mentioned scaly parts, or even the absolute stopping of the stigmata, does not prevent the buzzing, which he believes to proceed from the friction of the bases of the wings upon the solid parts surrounding them.

The Hymenoptera are for the most part of small or moderate size, few species exceeding two inches in length, or three in expanse of wings. A great number, especially of the parasitic forms, are exceedingly minute. They appear to be very generally diffused over the surface of the earth, but are probably more numerous in the warmer regions than in temperate zones. The number of described species is estimated at about 16,000, but this must bear only a very small proportion to the total Hymenopterous population of the globe. It has been estimated that we have about 3,000 species in Britain, and, making every allowance for the probable exaggeration of this estimate, owing to comparative want of thorough knowledge, we may believe that the number of species of Hymenoptera does not fall very far short of that of the Beetles in the British area; and, extending the argument to a wider field, it may be assumed that the Hymenoptera of the whole world are not much less numerous than the Beetles.

Geologically the Hymenoptera are not very ancient. Professor Heer has described a fragment of a wing from the Lias of Schambelen, in Switzerland, as possibly belonging to a species of Ant; but he is very doubtful whether it represents a Hymenopterous insect at all, and an inspection of his figure will show that his doubts are very well founded. Several species have been described as occurring in the Lithographic limestone of Solenhofen, in Bavaria, which belongs to the Upper Oolite; but these are regarded as doubtful by good authorities, and it is not until we reach the Tertiaries that unmistakable remains of Hymenopterous insects are met with. Here, however, they occur in all the deposits in which fossil insects are found, and are generally so nearly allied to existing types that they may safely be referred to the same families, and often to the same genera.

The classification of the Hymenoptera has undergone some superficial changes, although the views of entomologists as to the relations of the families have generally remained much the same. Latreille divided them into Aculeate and Terebrant Hymenoptera, according as the females were provided with stings or ovipositors, and the second group into Pupivora, with the abdomen attached to the thorax by a narrow part, and Securifera, in which the union of these two parts of the body is by the whole width of their bases. This arrangement was very generally followed for many years, and it seemed to be confirmed by the observation that throughout the whole of the Terebrantia of Latreille the trochanter consists of two rings, whilst in the Aculeata there is only one. The differences between the two great divisions of the Terebrantia are, however, so great and important, and the resemblances of the second of them to the Aculeata are so striking, that of late several leading authorities have adopted a triple division of the order, in which all the broad peculiarities of the insects are duly taken into consideration. This arrangement we shall adopt here, as it seems to enable all the affinities of the different families to be shown most distinctly. The three great tribes, or sub-orders, thus arrived at are as follows :—

I. Aculeata : having the trochanters simple; the abdomen attached to the thorax by a narrow part; the females provided with a retractile sting connected with a poison-gland; and the antennæ with twelve joints in the females and thirteen in the males. The larvæ are footless grubs, with no posterior aperture to the intestine.

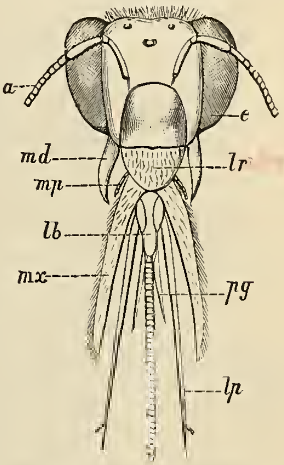
II. Entomophaga : having the trochanters composed of two rings; the abdomen as in the preceding; the females provided with an ovipositor, which usually projects from the body, and is enclosed by a sheath formed by two valves; and the antennæ with a variable and often very large number of joints. The larvæ are like those of the preceding group.

III. Phytophaga : the trochanters of two rings; the abdomen attached to the thorax by the whole width of its base; the ovipositor either a saw-like organ consisting of two valves, or an ovipositor nearly agreeing in structure with that of the preceding group; antennæ generally with a moderate number of joints. The larvæ are vegetable feeders, usually resembling Caterpillars, having six more or less developed thoracic legs, and generally a number of pro-legs on the abdominal segments; their alimentary canal has an anal orifice.

TRIBE I.—ACULEATA.

FAMILY APIARIÆ, OR BEES.

The chief characteristic of this family is to be found in the structure of the mouth, in which, as already described (p. 286), while the horny mandibles serve as biting organs, the labium is more or less elongated, as are also the maxillæ, the lobes of which are flattened like thin blades, which embrace the elongated ligula, the whole forming a sort of proboscis or tongue by means of which the insects suck or lap up the nectar of flowers. The ligula usually bears paraglossæ; the labium has four-jointed palpi; and the maxillary palpi have from one to six joints. The antennæ are more or less geniculate (Fig. 5, B, p. 284); in the males they are usually longer than in the females, and consist of thirteen joints, those of the females having only twelve. The eyes have the front margin entire; the vertex bears three ocelli; the wings, which have two or three sub-marginal cells, are not folded longitudinally in repose; and the posterior tibiæ and first tarsal joints are usually considerably widened, and clothed beneath with a brush of hair. In many the outer surfaces of the tibiæ are also a little hollowed, with long hairs growing from their margins, which renders them very serviceable in collecting and conveying to the nest the pollen of flowers. The surface of the body is in most Bees covered with hairs.



HEAD OF BEE (*Anthophora*).
a, antenna; *e*, eye; *md*, mandible; *lr*, labrum; *mx*, maxilla; *mp*, maxillary palpus; *lb*, labium; *pg*, paraglossa; *lp*, labial palpus.

The general appearance of Bees is pretty well known. They are generally rather stoutly-built insects, at all events for Hymenoptera, having a head of moderate or considerable size, antennæ of moderate length, an ovate thorax, and usually an ovate abdomen, although this last part is subject to considerable variation in point of shape. Their food in the perfect state consists almost exclusively of the nectar of flowers, which, as already mentioned, they lick up with the hairy ligula which forms the central piece of the proboscis. The larvæ feed upon nectar mixed with the pollen of flowers, and in all cases live in a cell, which is stored, or supplied at intervals during the growth of the larva, with the necessary stock of food. There is, however, great diversity in the mode of construction of these habitations, which are placed in very varied situations and composed of different materials.

Entomologists divide the family of the Bees into two great groups, the first of which is distinguished by having the tongue, or ligula, long and slender, and the labial palpi composed of two long and two short joints, the latter often stuck on at an angle close to the apex of the second long joint; while the second have a shorter and broader tongue, and labial palpi composed of four nearly equal joints, similar to those of the maxillary palpi. The first group includes the most typical of Bees, and especially the genus *Apis*, to which the Hive Bee belongs; it may therefore be denominated the sub-family *Apidæ*.


Queen. Worker. Male.
THE HIVE BEE.

The Hive Bee (*Apis mellifica*) would take a volume as large as the present for the due elaboration of its natural history, and such a volume might almost be written with less trouble than the short account that our space here compels us to give of it. We must, however, attempt to indicate in a few words the main outline of the natural history of an insect which, perhaps more than any other, has in all ages attracted the attention of mankind.

The ordinary Hive Bee, as is pretty well known, is a blackish-brown insect, clothed generally with greyish-brown hairs, with slight indications of paler bands on the abdomen. As a social species, it is, as already explained, represented by three adult forms, namely, males, perfect females,

and workers, or undeveloped females. These three forms are found together in the hive in the summer months; at other seasons only the two forms of females. Of these the perfect females are usually more brightly coloured than the workers; their general form is longer (the workers being half an inch and the females seven or eight lines long); the abdomen is long and tapering; the wings, when closed, do not reach the apex of the body. The eyes in both females and workers are of moderate size, and confined to the sides of the head. The males, or drones, are about as long as the females, but of a much stouter form of body; their wings are larger, and their eyes so large as to meet on the crown of the head. On the other hand, in the workers the basal joint of the posterior tarsi is concave, and marked across with ridges, each of which bears a fringe of bristles, making a sort of basket for carrying pollen. This apparatus is wanting in both the males and the perfect females.

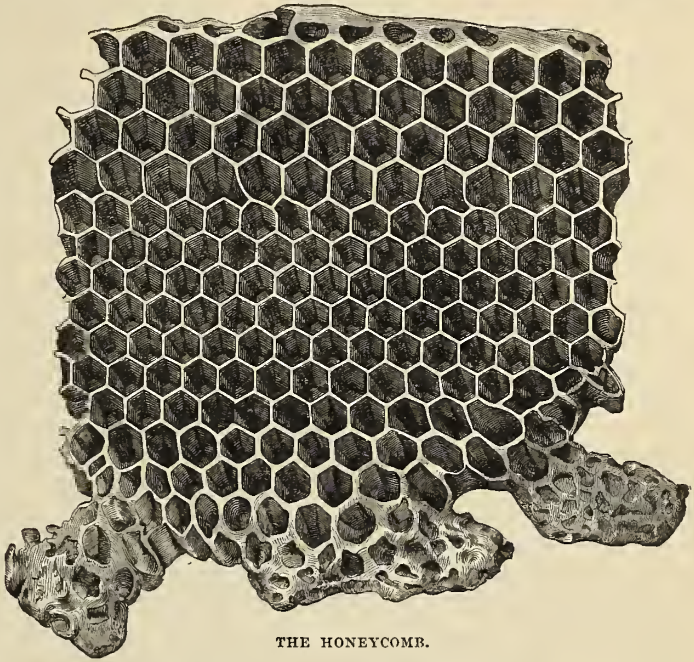
In Southern Europe, notably in Italy, a much more brightly-coloured Bee is found, distinguished especially by having yellow transverse bands on the abdomen. This Bee was long supposed to be a distinct species, and was described under the name of *Apis ligustica*, but it is now regarded as merely a variety, and, under the name of the Italian or Ligurian Bee, has of late been introduced into the more northern parts of Europe. Two other banded varieties (or species) are known in Africa, and another in China. As to the country in which the Hive Bee originated, nothing can be said. It appears to have been known since the earliest dawn of history, and is now in one or other of its forms spread over nearly the whole surface of the earth, and in some localities in warm climates is even found in a wild state, but whether truly wild or only escaped from captivity is a question.

In all cases, however, the habits of the insect are the same. The nest is built in the protection of some hollow in the wild state, usually in a hole of a tree; under domestication, in a hive of some sort. It would be futile to attempt any description of the immense variety of hives which have been invented to serve as the homes of Bees. The old straw hive, the appearance of which must be familiar to every one, has no doubt come down to us from a very remote antiquity, and was the only form known during the long period in which the cultivation of Bees was a matter of great importance. The introduction of a second hive, or "super," placed above the one in which the Bees live, so as to enable the produce of their industry to be removed without sacrificing the Bees, was a great step in advance; and the employment of wooden hives with glass sides, enabling the whole economy of the community to be easily superintended, has not only revealed to us most of the secrets of Bee-life, but at the same time placed the management of the hive completely in the hands of the owner. At the present day the Bee-keeper can actually govern the reproduction of his stock, by introducing into the hive the foundations of cells of the size proper for receiving male or female eggs.

During the winter and spring the community consists exclusively of female individuals, namely, a single perfect female or "queen," and a multitude of workers. The business of the former is to lay eggs; that of the latter to perform all the necessary operations for the maintenance of the hive and the support of the young.

The actual nest, if we may call it so, built by the workers within the hive, consists of a series of so-called "combs" suspended perpendicularly side by side within the cavity of the hive, and formed of numerous hexagonal cells laid horizontally, that is, at right angles to the general direction of the comb. Each comb consists of two sets of cells opening on its opposite sides, and therefore placed end to end and separated by a very thin plate of material; and it is remarkable that the cells are not placed directly end to end and terminated by flat surfaces, but so that each cell is closed by portions of three cells on the other side of the comb, an arrangement which, as will be seen, insures a certain economy of space. Thus, the cell, which is a hexagonal prism, is terminated by a small pyramid composed of three rhomboidal faces, and as these belong to three cells on the other side, the apex of the pyramid, forming the deepest part of the cell, is placed at the junction of three sides of the cells on the other side of the comb, so that the deepest parts of the cells on one side fit into the shallowest parts of those on the other. This marvellously ingenious arrangement has long excited the admiration of mankind, especially since it was found that both in the form of their cells in the form and arrangement of the pieces closing them, the Bees approximated very closely to the proportions which, according to theory, were most advantageous. The accurocy of Bee architecture was, indeed, a little exaggerated, as such an example suited admirably a certain school of writers whose delight it was to undervalue all manifestations of the human intellect. Nowadays, this sort of

misplaced enthusiasm is fortunately going out of fashion, and we can admire what is admirable in the architecture of the hive and in the wonderful polity of its inmates, without ascribing almost miraculous powers to the latter. The Bee's cell is a hexagonal prism, because the insect endeavours to get as many cells of proper size as possible into the space at its command; and the hexagonal prism is the form most nearly approaching a cylinder, any number of which of equal size may be placed side by side without leaving any vacant spaces between them. The cells may therefore be regarded as attempted cylinders which have become converted into six-sided prisms by what may be called mutual pressure. This is further evidenced by the fact that the cells close to the part where the comb is attached for suspension, and some of those at the junction of rows of different sizes (see figure), are more or less irregular in form; and also that those which occupy the free edges of the comb follow the prismatic form only on the side turned towards the solid comb, the outer surface being irregular or rounded.



THE HONEYCOMB.

The same inherited instinct that prompts the Bees to build these elaborate double combs also teaches them that, in order to effect their object, namely, the production of the largest number of cradles for their young, in the smallest possible space and with the smallest expenditure of a valuable material, they must adopt the principle of making the cells alternate on the two sides of the comb, and their adoption of this plan furnishes the explanation of the whole phenomenon. The material used, as is well known, is wax, a peculiar substance secreted by the workers from between the segments of the abdomen. When this secretion is going on, the workers engaged in it cling together in numerous festoons, forming a mass that has been compared to a curtain, and the process may last for some four-and-twenty hours. When the secretion of the wax is completed, it projects from between the abdominal segments in the form of thin plates, which the Bees then proceed to detach and make use of in comb-building. It is taken in fragments into the mouth, where it undergoes a process of mastication, and is probably moistened with some fluid which renders it easier to work; finally it issues from the mouth of the Bee in the form of a small white riband. The place for the formation of a comb having been selected, the wax-producing Bees build up a small plate of wax, usually of a nearly semicircular form, upon the line corresponding to the partition of the future comb, and this at first has no indication of cells. But when the first small plate has been got together the Bees go to work upon it and dig out small hollows in its substance, which they afterwards enlarge, working simultaneously on both sides, and reducing as much as possible the thickness of the partition between them. As the Bees do not work directly opposite to one another, the deepest part of the hollows on one side will correspond with

UNDER SURFACE OF BEE, SHOWING THE WAX BETWEEN THE SEGMENTS.

partitions between the hollows on the other. As the hollows are approximately equidistant and of the same size, each hollow is opposed to parts of three on the other side of the plate; and as the Bees are constantly working on both sides for the purpose of thinning the partition wall, a time would speedily come when each curvilinear hollow would be broken through in three places unless they ceased or modified their operations. This is precisely what they do. They avoid piercing the partition, but by subsequent action upon both sides of it produce exactly the same effect that would be produced by the mutual pressure of the same number of plastic bodies with a similar curvature, namely, the formation of flat limiting planes, of which each cell has three. As the same operations are going on all round, the original circular form of the hollow becomes converted into a hexagon, and thus the three terminating plates acquire the rhomboidal form that we see. In this way the foundation of the comb is laid, and the plan of the hexagonal cells which are afterwards built is marked out.

Of the formation of the cells we need say but little. The plan being sketched, or rather, perhaps, as the plan is being sketched (for it must be remembered that operations which we have to describe in succession may be simultaneously carried on by a crowd of little artificers like the Bees of a hive), the Bees begin to raise the edges of the hollows representing the bottoms of the cells, and these are built up to the required height by additions of wax moulded and worked by the Bees to the requisite degree of thinness. The building progresses rapidly downwards. New cells are commenced long before the earlier ones are finished, so that the increasing comb is thickest at its point of attachment, and becomes thinner towards the edges, and especially towards the bottom. In fact, it is not until the comb is completed that it acquires those nearly parallel surfaces which we are accustomed to see in ordinary honeycombs. When the first comb has advanced a little, the Bees lay the foundation of other combs parallel to and on each side of it, and at the proper distance apart; and as the cells are completed, they finish them off by applying round the edges and along the lines of junction of all the waxen plates composing them a thin coating of the resinous substance called *propolis*, which they collect from the opening buds of poplars and other trees, and employ for a variety of purposes in the economy of the hive, especially for stopping crevices, fixing loose parts, and covering up noxious objects which are too heavy for them to remove.

The cells in the combs are of different sizes, according to the use to which they are to be put. Those for the rearing of worker-larvæ are the smallest, and worker-combs are about an inch in thickness. Drone-cells are of larger diameter, and rather longer than those of workers; hence drone-comb is thicker than worker-comb, and when patches of drone-cells occur in the midst of worker-cells the comb becomes deformed and irregular. Besides these two kinds of comb-forming cells, there is a third of the same general shape and construction, specially designed for the storing of honey. The cells forming store-combs are generally as wide as drone-cells, but much longer—sometimes as much as an inch and a half in length. The passages left between the parallel combs are about half an inch wide.

As the brood-cells are completed by the labours of the workers, the queen proceeds to deposit her eggs in them. She first inserts her head into the cell, as if to see that it is properly prepared for the reception of its new tenant; then, withdrawing her head, she bends her body down into the cell, turns half round, and deposits an egg at the bottom of the cell. This process is repeated at each cell, and it is remarked by bee-masters that the queen usually deposits her eggs equally on both sides of the comb, which may no doubt assist in economising the warmth of the brood. In a populous hive there may be from 40,000 to 50,000 workers, incessantly engaged in the various operations of the hive, of which the preparation of cells for the reception of the eggs is one of the most important, as may be supposed when it is estimated that a vigorous queen will lay from 2,000 to 3,000 eggs daily in the height of summer, or, as Dzierzon calculates, 60,000 a month, and during her average life of four years over a million eggs. This extreme fertility is the more surprising as the eggs produced are of comparatively large size—nearly one-twelfth of an inch long. It is to be observed, however, that the queen, when laying, is always accompanied by an obsequious crowd of her subjects, not only ready, but urgent, to furnish her with an abundance of food, so that she may be compared to a machine receiving food as a raw material, and incessantly converting it into eggs, and turning out the finished articles at the rate of about 100 per hour.

The egg, which is of an elongated form, and slightly curved, is deposited on the bottom of the cell by one of its ends. The cell is then furnished by the workers with a small mass of a peculiar jelly elaborated by the workers from a mixture of honey and pollen, and disgorged by them into the cells. On the fourth day the larva is hatched, and, having consumed the food placed ready for it, stretches itself towards the mouth of the cell, and is then abundantly supplied with food by the workers. Under these favourable circumstances it grows very rapidly, and in six or seven days attains its full size, and fills up the whole cell. The workers then cover the cell with a sort of lid, composed of wax mixed with pollen, and thus protected the larva soon spins a silken cocoon, within which it casts its skin for the first time, and becomes a pupa, with the wings and limbs enclosed in separate cases. On the twenty-first day the perfect insect emerges, and after a delay of a few hours, during which the various parts of its body dry and harden, it at once begins to take part in the various labours of the hive, but does not venture out for a week or a fortnight. As soon as the insect has emerged from its cell, the latter is cleaned out and prepared for the reception of a new inmate; but as the cocoons are left behind, and a certain amount of dirt clings to the used cells, these gradually become dark in colour and reduced in size by the accumulation of cocoons, an effect speedily made perceptible by the smaller size of the workers produced from the old combs. The workers, which generally live only about six weeks in the height of the season, continue to be produced, when the weather is favourable, until October. The business of these workers, besides the building of the cells and care of the young, as already indicated, consists chiefly in the bringing in of supplies of honey and pollen, both for immediate consumption and to be stored against the flowerless season of the year. In pursuit of these substances, the worker-bees are incessantly on the wing during fine weather, passing busily from flower to flower, and when loaded flying straight home to their own hive, to which they are directed by an instinct of locality which is perfectly marvellous. At the end of the year, and during the winter, parts of the combs are entirely filled with honey, which is also found occupying the upper rows of cells in most of the combs, while the remainder are either empty, waiting for the next season's brood, or filled with pollen, or "Bee-bread," as it is called, carefully laid up, and, like the honey, shut into the cells by little waxen lids. The pollen is carried home chiefly upon the dilated hind legs, the honey in the sucking-stomach, from which it is disgorged either for the supply of the larvæ or into the store-cells.

During the winter, the Bees remain congregated in the hive, where they keep up their heat by close packing and a certain amount of exercise. The temperature of the hive rarely falls below 45° Fahr. Activity usually recommences in April, and the first business is a general "house-cleaning," including the removal of the bodies of those Bees which have died during the winter, the repair of any damage that may have happened to the combs, and the clearing out of the numerous wax-lids, detached from the cells of which the honey has been consumed, which lie about as they fell upon the floor of the hive. These necessary operations having been performed, the Bees, if the hive has not suffered much during the winter, set about the preparations for a new phase in their existence, namely, the emigration of a portion of the population to found a new hive. Drone cells are prepared, and in each of them the queen lays an egg. The workers furnish the larvæ with the necessary food. They become full grown on the eighth day of their existence, and the cells containing them are then closed up with a lid in the same way as those of the worker-bees. On the twenty-fourth day after the laying of the egg the lids open, and the drones or males come forth.

As the drones begin to make their appearance another form of cell is produced, generally on the margins of the combs. Here the workers make a more or less irregular chamber, usually with its mouth turned downwards, and in which, instead of endeavouring to be sparing of material, they seem recklessly to employ a quite unnecessary quantity. In this cell the queen also lays an egg,* and the larva, when hatched, is fed by the workers throughout its life in that state with the peculiar jelly-like

* This is the general impression; but some bee-masters, and among them Mr. John Hunter, whose "Manual of Bee-keeping" is one of the most intelligent books on the subject, is of opinion that the queen does not lay in the royal cells, but that the workers, when they consider it necessary to produce new queens, take eggs already laid in worker cells, or even young worker larvæ, and enclosing them in royal cells, feed them with royal jelly, and thus produce the young queens. That a new queen can be produced in this way should the hive be accidentally deprived of its sovereign is a perfectly well-known fact.

food which constitutes the first meal only of the worker larva. The consequence of this difference of treatment is that the larva attains its maturity in six days, when it is closed up in the usual manner, becomes transformed into a pupa, and in sixteen days gives birth to a fertile female or queen. As the queen-bees are so jealous that two of them cannot live together in the same hive, the old queen, when she becomes aware of the presence within her realm of a possible successor, becomes much agitated, and would doubtless destroy the young female, whose existence is betrayed by a sharp piping sound, if the workers did not carefully keep the latter in her cell. In course of time the agitation of the old queen becomes extreme, and communicates itself to the other Bees in the hive, which grow exceedingly disquieted, display great activity, and in consequence raise the temperature of the hive to an almost unbearable pitch. This is generally revealed by a tendency on the part of the Bees to issue from the hive in great numbers, and by clinging together suspend themselves in a compact mass just outside the entrance to the hive. This process is called "clustering," and is generally to be taken as an indication that "swarming" is about to take place. Sooner or later, at any rate, a great swarm of Bees, frequently numbering ten or fifteen thousand in strong hives, will rush out of the hive, carrying with them the old queen. They spread in every direction through the air, often to such an extent as to have been compared to the flakes of a heavy fall of snow. In a few minutes, however, the queen, who, from being heavy with eggs, cannot fly far, and some of the Bees, settle upon the branch of a tree or some other projecting object; others collect upon these, until at last a large ball of Bees is formed, having their queen in their midst. This is taken into a new hive, and constitutes the foundation of a new colony.

The young queen's first thought on escaping from the cell in which she was reared is to proceed at once to destroy any sisters that she may happen to have, and in this seemingly unnatural course she is abetted, and even aided, by the workers, unless their instincts tell them that further swarming will be immediately necessary for the well-being of the hive. In the latter case they prevent their new sovereign from carrying out her murderous intentions, and, according to some writers, will, with this object in view, treat her very unceremoniously.

From two days to a week after her emergence the young queen takes her nuptial flight, for in the Bees, as in many other insects, the union of the sexes always takes place in the air. Whatever may be its object there is no doubt that this is what occurs in the Bees, and there is ample evidence that the nuptials of these insects are celebrated during flight. In quitting the hive the young queen is described as taking a careful survey of it and its surroundings, apparently so as to identify it on her return. She then starts off and is soon out of sight. A day or two after she has returned to the hive she usually commences her regular maternal duties, which she continues to perform without ever quitting the hive, until she goes forth as the leader of a swarm.

According to some experienced Bee-keepers the drones of the hive do not take to flight with the young queen, but the nuptial flight is undertaken with the purpose of meeting drones from other hives, and thus securing the benefits of cross-fertilisation. Later princesses produced in the hive go off as the leaders of after-swarms, and these we might certainly expect to be impregnated by drones from other stocks. But, on the other hand, we have the remarkable fact that as soon as all the fertilisable females have emerged from their cells or been destroyed, the surviving drones, as though considered no longer of any use, are ruthlessly massacred by the workers, and thrown out of the hive.

It has already been mentioned that in the Bee, and probably in other social Hymenoptera, workers occasionally occur which possess a certain limited fertility. These workers in the case of the Bee always produce drone-eggs; and in fact it was the recognition of this fact that led originally to the establishment by Von Siebold of the theory of the constitution of the Bee community, which is now generally accepted. These partially fertile workers, which become a nuisance in the hive, have part of the ovaries sufficiently developed to produce eggs, but, as they are incapable of impregnation, these eggs cannot be fertilised, and hence produce only drones. Why the partial development of the ovarian organs takes place is not known with certainty, but it may be inferred with considerable probability that the larvæ of these workers were brought up in cells near the royal cells, and that some portions of the food intended to bring the young queens to maturity fell to their share.

That we have devoted so much space to the natural history of the Honey Bee is due to the fact

that it furnishes an example of the most perfect society that we shall have to notice, and hence the explanations here given will serve to render intelligible the much shorter accounts that we must give of the other social types. But the preceding description is necessarily very imperfect, and hundreds of interesting points have been left altogether untouched. Of the economical importance of the Bee, and of the methods of its cultivation and treatment in various countries, we have been perforce silent. The principal enemies of our Bees are the larva of the Honeycomb Moth (*Achroia alvearia*), that of a small beetle (*Trichodes apiarius*), and the great Death's Head Moth (*Acherontia atropos*). A small insect known as the Bee Louse (*Braula cæca*), which belongs to the order Diptera, although it has no wings, lives as a parasite upon the Honey Bee.

Nearly related to the Hive Bee are numerous wild Bees inhabiting various parts of South America, and forming the genera *Melipona* and *Trigona*, those of the latter generally of very small size. Like the Hive Bee these are social in their habits, build their cells with wax (which, however, is said to escape between the dorsal instead of the ventral scales of the abdomen), and store up honey. They generally live in hollow trunks of trees, but also in holes and fissures in the ground, and line their residences with clay and resinous materials. In the use of their wax for the formation of the brood-cells and store-places they are by no means so economical as the Hive Bee. The former are in a single row in each comb, thick-walled, and with rounded bottoms; the combs are placed horizontally, and the upper ones supported by waxen pillars, and the openings of the cells are turned *upwards;* the store-cells are of large size, irregularly ovate, and massive. These insects possess no stings, but bite severely.

The HUMBLE BEES (*Bombus*), of which we have some eighteen British species, are too well known as to their general appearance to need any description. Large, heavy insects, flying buzzing along in the summer air, they present a considerable contrast to the much lighter Hive Bee, and in their habits also a similar contrast prevails. The genus is very widely represented, species of it occurring in Europe, Asia, and America; and, although it appears to belong properly to the northern regions, several species are found in South America. None, however, are known to occur in Australia, New Zealand, or Africa. The individuals vary greatly, especially the males, which renders the determination of the species often a matter of considerable difficulty.

Like the Hive Bee, the Humble Bees are social, but their societies are not permanent. In fact, they are rather families than societies, for each community springs in the course of a single season from a female which has survived from the previous year. These females are to be found hibernating in moss at the roots of trees, in the hollows of decayed trunks, under stacks, and in other dry and sheltered situations. With the first genial weather of spring each of these sets to work to prepare a nest and found a new colony. The nests are built either in or on the ground—in the former case the foundress Bee often takes advantage of some burrow or other ready-made cavity; in the latter the nest is usually composed of moss, although other materials, such as dried grass and leaves, are often employed. The nest first made is a very small affair, intended to serve only for rearing a few workers to take part in their mother's labours. The female makes no cells for the reception of her progeny, but brings into the nest a quantity of pollen and honey, which she places in a heap, and then lays some eggs in it. The larvæ from these, when hatched, feed freely on the store of food provided for them, and on the further supplies brought in during their growth by their mother. Like the larvæ of the Hive Bee they grow very quickly, and in a few days become full grown, and prepare for their change to the pupa state by spinning a silken cocoon, which is so delicate as to be almost transparent. In this they pass their period of repose, and, in emerging from the cocoons, gnaw through one end of them. The empty cocoons, placed side by side with these openings upwards, resemble so many little pots, and serve afterwards as vessels to store supplies of food. Later on, besides more workers, some small females, which are supposed to lay only drone-eggs, make their appearance, and, about the same time or later, drones are produced. Then towards autumn large females, similar to the original foundress of the colony, show themselves in the nest, and these, after impregnation, conceal themselves in sheltered places to pass the winter as already described.

Several species of Humble Bees are very common in this country, and most of these are widely distributed on the continent of Europe. One of the best known is the *Bombus terrestris*, the large

females of which may attain a length of nearly an inch. It is thickly covered with black pubescence, but with the front of the thorax, a band across the middle of the abdomen, and its extremity yellow. In another rather smaller species (*Bombus lucorum*) the colours are the same in the female and worker, except that the extremity of the abdomen is white; but the male is clothed with yellowish pubescence, except the apical portion of the abdomen, which is white, and some more or less distinct black bands on the thorax and abdomen. Both these species are subterranean Bees. Of the moss-builders, the best known perhaps is the *Bombus muscorum*, the largest specimens of which are about two-thirds of an inch long. This is clothed with dull yellow pubescence, which becomes tawny on the thorax, and shows more or less distinct traces of black bands on the abdomen. *Bombus lapidarius*, so called from a preference it shows for making its nest under stones, is the well-known large black Humble Bee, with the end of the abdomen orange red. The male has the face, the front of the thorax, and the scutellum yellow.

The numbers of individuals in the nests of the Humble Bees are very small when compared with the multitudes which swarm in a bee-hive. According to the late Mr. Frederick Smith, those of *Bombus terrestris* contain the largest number known to him, and he records that a nest of this species taken in August contained only thirty-five females, twenty males, and one hundred and sixty workers; whilst in a nest of *B. fragrans* at the same season only five females and about twenty workers were found.

APATHUS VESTALIS.

These true Humble Bees, which are among the most industrious of insects, passing their lives in incessant activity, and bringing in large supplies of pollen and honey to their nests, are provided, like the Honey Bee, with greatly-dilated hind tibiæ and tarsi, thickly fringed with long bristle-like hairs, which render them efficient instruments for the conveyance of pollen. There are, however, certain nearly-allied Bees resembling them in general characters, and even in the dilatation of the hind tibia and first tarsal joints, but in which these dilated parts are destitute of the hairs and bristles which render them so useful as pollen-baskets, so that at the first glance one would conclude that they cannot follow the same mode of life as the true *Bombi*. In point of fact, these Bees, which have been formed into a distinct genus under the name of *Apathus*, are parasitic upon the true Humble Bees, visiting their nests, depositing their eggs there, and leaving the care of rearing the larvæ to their industrious relatives. Four British species are recorded, the most abundant of which are

Apathus Barbutellus, a black species about three-quarters of an inch long, which has the front of the thorax and the scutellum tawny, and the apex of the abdomen white; and *A. vestalis* (see figure, p. 366), which is rather larger and also black, with the front of the thorax orange-yellow, and the end of the abdomen white, with a blackish or brownish spot at the apex. Of these insects there are only perfect males and females. From their habits no workers are necessary.

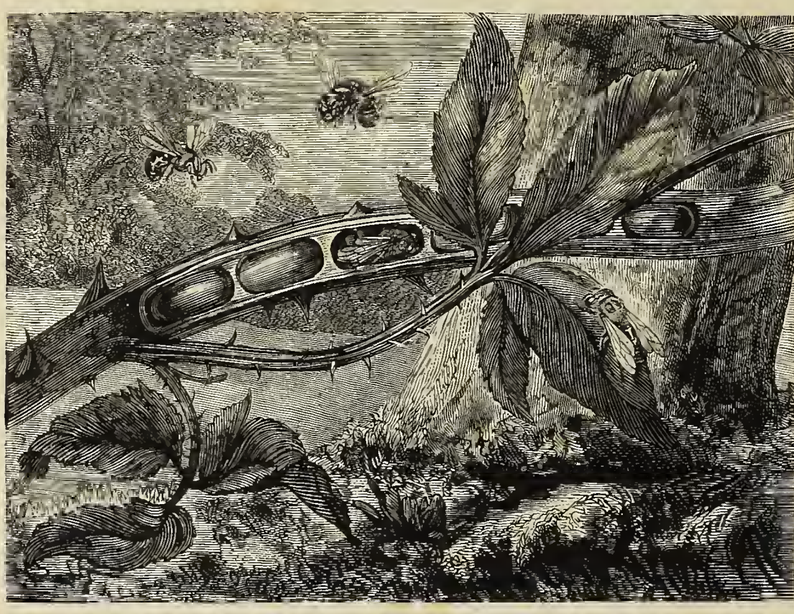
In the Humble Bees we have the conditions of social Bee-life reduced to their simplest form. There are workers, it is true; but the females also labour. The nest is really a family dwelling. No cells are formed, and the larvæ feed upon a mass of pollen and honey brought into the nest. In the Solitary Bees, which form the remainder of the family, we have, in a slightly modified form, the same series of phenomena that are involved in the first foundation of the Humble Bee colony. The female Bee makes her nest, stores it with food, and deposits her egg upon the latter; but she lays in a sufficient store for the support of the larva until it attains its full growth, and then closes up the nest, and leaves it to itself. The larva, having consumed the provision laid up for it, spins a cocoon, and undergoes its change to the pupa state, in which it usually remains until nearly a year has elapsed from the time of the egg being laid, and then the perfect Bee makes its way out to seek its mate and provide for the continuance of its species.

In their habits, these Solitary Bees show considerable diversity. A great number bore holes in decayed wood, such as old posts and trunks of trees; others select the stems of such plants as brambles and briars, from which they bore out the pith, making a tubular nest which they occupy with their cells. Some of these, again, save themselves the trouble of hollowing out a nesting-place by the simple process of making use of the ready-prepared tubular cavities offered to them by the straws of thatch, cut reeds, and similar articles. A great number burrow in the ground, some selecting sandy, others clayey situations, but generally in the face of a sloping bank or cliff; and others, again, pierce the mortar of old walls, and there form the cells for their young. These cells are not composed of wax, but either of earthy or vegetable materials, and we need not say that they never possess the beautiful hexagonal form characteristic of those of the Hive Bee.

Of the Scopulipede Solitary Apidæ, or those furnished, like the Hive Bee and the Humble Bee, with an apparatus for the conveyance of pollen on the hind legs, we may notice, in the first place, a very common spring Bee, the *Anthophora acervorum*, the female of which resembles a rather small black Humble Bee, with the hairs on the hind legs reddish-tawny, whilst the male is clothed with tawny hairs, and has the intermediate legs much elongated, slender, and adorned with curious fringes of black hairs. This Bee swarms in the neighbourhood of banks and cliffs as early in the year as April. Its burrows are made in such situations, and occasionally in the mortar of old walls, barns, &c.

The VIOLET CARPENTER BEE (*Xylocopa violacea*), which belongs to a genus best represented in warm countries, inhabits the south of Europe, but extends northwards into Germany. It is a large insect much resembling a Humble Bee, of a black colour, with violet wings, upon which it flies noisily in the sunshine, seeking a suitable place for its nest, for which it usually selects a wooden post or the dead trunk of a tree. Having chosen a favourable position, the female sets to work with her powerful jaws, and speedily gnaws straight into the wood for a short distance, and then, turning downwards, proceeds to excavate a large tunnel in the interior of the post or tree, sometimes for a distance of a foot or more. This laborious work being completed, the industrious insect collects a quantity of honey and pollen, which she deposits in the bottom of the nest. Upon this she then lays an egg, and covers up the whole with a roof composed of concentric rings of the fine dust produced during her boring operations carefully kneaded together. This serves at once as a ceiling for the first cell and a floor for the second. Upon it a fresh supply of food is deposited, with another egg, followed by a second transverse partition, and the same processes are repeated until the whole tubular dwelling is occupied. There is some reason to think that in the warmer countries inhabited by it there are two broods of this Bee in the course of the summer. The *Xylocopæ*, although so scantily represented in Europe, have over 100 species in the tropical parts of the earth. The nearly allied genus (*Euglossa*), found in South America, is remarkable for the great development of the tongue, which is two-thirds the length of the body. One fine species, over an inch long (*Euglossa dimidiata*), found in Brazil and Surinam, is velvet-black, with a metallic-green abdomen, having three transverse bands of yellow hairs, and the extremity clothed with bright red hairs.

Closing our account of the Scopulipede Bees with this brilliant foreigner, we must now proceed to notice a few types of another group, to which the name of Dasygastres has been given, in allusion to their having the lower surface of the abdomen densely clothed with hairs, upon which they collect and convey home the pollen for the supply of their young. These Bees, represented in Britain chiefly by the genera *Osmia* and *Megachile*, present a most interesting variety of habits, and, in fact, examples of all the peculiarities already mentioned, modified in various ways, may be observed among them. Of the first of these genera, Mr. Frederick Smith, in his "Catalogue of British Bees," says :—"If I were asked which genus of Bees would afford the most abundant materials for an essay on the diversity of instinct, I should without hesitation point out the genus *Osmia*." A species described by Réaumur under the name of the Mason Bee (*Chalicodoma muraria*), nearly allied to *Osmia*, builds its nest, composed of fine sand-grains very firmly united by a salivary secretion, upon the surface of walls, selecting, in the first place, some small cavity or hollow which may help to give a firm foundation. Here the insect builds a cell somewhat resembling a small finger-stall, with the opening upwards, smooth on the inside, rough outwardly. When nearly completed this cell is furnished with a supply of food, and an egg is laid in it; then the top is closed, and the industrious mother sets to work to build another cell, and this process is repeated until circumstances induce the female to seek another place. The cells are placed without any particular order, and Dr. Taschenberg says he has never seen more than ten together. This Mason Bee has not hitherto been found in Britain.



OSMIA LEUCOMELANA AND ITS NEST.

The most abundant British *Osmia* is the Horned Bee (*Osmia bicornis*), of which the female is remarkable for having two little horns projecting from the front of her head. This species usually burrows in sandy banks and cliffs, but when living in clayey districts chooses decaying trees, especially willows, for its nests. Another species (*Osmia leucomelana*) selects for its breeding-places the dead branches of the common bramble, the pith of which it scoops out to a depth of several inches, and then deposits its eggs, with a supply of food, in a series of cells separated by partitions formed of masticated vegetable matter. This Bee shows great ingenuity, for it does not remove the whole of the pith, but leaves portions projecting in the form of rings, which help to make the partitions between the cells. *Osmia hirta* and some other species burrow into wood; whilst two British species (*O. aurulenta* and *bicolor*) select ready-made nests in the shells of the common snails (*Helix hortensis* and *H. nemoralis*), within the whorls of which they build their cells of gnawed vegetable materials.

The nearly-allied Bees of the genus *Megachile* are commonly known as Leaf-cutters, from the habit they have of cutting portions of the leaves of trees and plants for the purpose of lining their nests. The pieces of leaf are cut by the mandibles with the utmost neatness, and when detached are carefully rolled up, tucked between the legs, and flown away with to the nest. The rose, laburnum, and garden acacia seem to be the favourite trees with these insects, which form their nests in

60 LEAF-CUTTING BEES AND NESTS.

burrows, either in the ground or in decaying trees, and line them neatly with the portions of leaves so arranged as to separate the different cells, which roughly resemble so many thimbles placed one within the other. The commonest British species (*Megachile centuncularis*) is very widely distributed, being spread apparently over nearly the whole northern part of the globe. An allied species, the Poppy Bee, the Upholsterer Bee of Réaumur (*Anthocopa papaveris*), is remarkable for choosing the petals of the common poppy as the material for lining her nest.

As in the case of the Humble Bees, there is a contrast to this picture of industry. Several genera of true Apidæ do not take the trouble of preparing or storing any cells for their young, but foist their progeny upon their more industrious relatives. These Cuckoo Bees, as they have appropriately been called, may be distinguished by their want of any apparatus for collecting pollen, either in the form of dilated hind legs furnished with bristles, or in that of a thick coat of hairs on the lower surface of the abdomen. The best-known of these parasites are the species of the genus *Nomada*—slender, smooth, shiny insects, more like Wasps than Bees, and generally adorned with bands of yellow and black, or red. These gaily-coloured insects may be observed flying about the sunny banks in which other Bees delight to form their nests. They make their way into the nests in the absence of the rightful owners, and deposit their own eggs upon the masses of food stored up for the intended occupant. It seems probable that the nest-making Bee, finding on her return that an egg has been laid, takes it for granted that it is one she has deposited, and forgotten, and so closes up the cell; but Mr. F. Smith was of opinion that the *Nomadæ* themselves might perform the latter operation, as he had occasionally observed these parasitic Bees with small masses of clay attached to their hind legs.

MASON BEE.

A, Male in flight; B, Female working at Nest; C, Female in front; D, A Completed Nest.

The second principal group, or sub-family, of Bees, called *Andrenidæ*, from the name of the principal genus, includes no social species. As already stated, the tongue in these Bees is short and broad, and the labial palpi consist of four nearly equal joints, like those of the maxillary palpi.

The true *Andrenæ*, of which a great number of species inhabit this country, are all burrowers in the ground, sometimes in banks of light sandy earth, sometimes in firm soil, and even in hard-trodden pathways. Their burrows run to a depth of several inches, and terminate usually in a single oval cell, but occasionally the Bee makes branching tunnels, so that a single entrance passage

may serve to give access to several cells. In the nearly allied genus *Halictus* (or *Hylæus*) this habit of multiplying the cells seems to be general. In all, the cells terminate the tunnels, and when stored with food and furnished with eggs the female closes the aperture of the burrow. As a general rule the development of these burrowing Andrenidæ takes place in the following fashion :—The larva, when hatched, feeds upon the supply of food left for it, undergoes its change to the pupa state, and in this condition remains in its cell through the winter, to emerge at the same season of the year at which the egg was laid; but in some cases there appear to be two broods in the course of the year; and in *Halictus* and an allied genus (*Sphecodes*) it would seem that the insects escape from the nests in the autumn, and the females, after impregnation, survive the winter in sheltered places, and commence their nest-making operations in the spring, thus following the same course as the Humble Bees. The species of *Sphecodes* are very unlike Bees in their general appearance, being generally smooth black insects, with more or less of the abdomen red, and the females have no apparatus for carrying pollen either on the legs or the abdomen. Other species of this group, especially those of the genus *Prosopis*, have been observed to make their nests in bramble-sticks.

The Andrenidæ are particularly subject to the attacks of those peculiar parasites which infest Bees, especially the coleopterous Stylopidæ and Meloidæ.

FAMILY VESPIDÆ, OR WASPS.

The Wasps, which, like the Bees, are both social and solitary in their mode of life, form the second family of the aculeate Hymenoptera, called Vespidæ, from the name of the genus (*Vespa*), which includes the best known species. One of their most striking characters is to be found in the fact that the fore wings, which, as in the Bees, have either two or three submarginal (or cubital) cells, are capable of being folded down the middle, so that the wings of each side of the body form a straight band only about half the width of the fore wing. The first discoidal cell is very long, being much produced towards the base of the wing. In their general structure they approach the Bees, but are of a more slender form, and usually much less hairy. The posterior tibiæ and tarsi are simple and not dilated; the sides of the prothorax are produced back as far as the root of the wings; the antennæ are, as in the Bees, more or less kneed at the end of the long first joint; the eyes are kidney-shaped; the mandibles well developed and prominent; and the maxillæ and labium do not, as in the Bees, form a sort of proboscis. The labium is wide in front, and its palpi are either three or four-jointed; the maxillary palpi consist of six joints. Species of this family occur in nearly all parts of the world, and about 1,000 of them are known.

The social forms, which, in the beauty of their architecture rival, if they do not excel, the Hive Bee, are distinguishable from the solitary ones by certain structural peculiarities; the claws at the ends of the tarsi are simple, and the mandibles are broad. These insects live in communities of various sizes according to the species, consisting, as in the Bees, of three kinds of individuals, males, perfect females, and workers. Their nests, which are among the most beautiful examples of insect architecture, are found either in holes in the ground, or in hollow trees, and similarly sheltered situations, or freely suspended from the twigs or branches of trees. The material of which they are composed is a sort of rough paper or cardboard, composed of portions of plants, usually woody in their nature, gnawed up by the insects and brought into the condition of a paste by means of their salivary secretion, which is of so viscid a nature as to hold the particles of vegetable matter very solidly together. In fact, the material of which the nests and cells are constructed often shows a marvellous smoothness of surface; the workmanship of the cells is always of great beauty. The cells are hexagonal in form and placed side by side so as to form regular combs, but there is only a single row of cells in each comb, and in most cases their apertures are turned downwards. The combs as they increase in number are placed one above the other, and usually attached to each other by small columns of the paper-like material of which the nest is composed.

Although some of the nests may contain several thousand individuals, and a much larger number of cells, each community (at any rate in temperate climates) originates from a single female Wasp, which, having arrived at maturity and been impregnated in the preceding autumn, and passed the winter in a state of torpor concealed in moss, or some other shelter, comes forth with the first mild days of spring and lays the foundation of the nest. The proceedings of this foundress of the colony are so

well described by the late Mr. Frederick Smith, that we cannot do better than quote his account of them. It relates apparently to the Common Wasp (*Vespa vulgaris*), and is as follows:—"Having found some hole in a situation adapted to her purpose, she proceeds to enlarge it and to form a subterranean chamber of suitable dimensions. Her next operation is to collect materials wherewith to lay the foundation of the nest itself. This is constructed of the raspings or scrapings of different kinds of wood. Having produced a supply, she first constructs a footstalk sufficiently strong to support the first two or three layers of cells. At the end of the column or footstalk she forms three cup-shaped receptacles; these are of course reversed, hanging bellwise; the depth of each is about the tenth of an inch. The Wasp now constructs a covering over the foundation-cells like an umbrella. An egg is deposited in each cup, and she then proceeds to construct additional ones, depositing an egg in each as soon as completed. By this time the eggs first deposited are hatched, and the larvæ now require a portion of her attention. The larvæ of Wasps grow rapidly, and, with the growth of the grubs, she from time to time raises the walls of the cells. The cells in the foundation-comb are never carried up higher than the length of the larva. As it increases day by day, the Wasp adds a fresh course of wall until the larva is full grown, when it covers itself in by spinning a convex cap to the cell of a tough, white, silky texture. The angles of the planes of the hexagons are determined by the points of contact of the circular bases. From these the Wasp gradually commences the flattened sides of the hexagons, at first a little curved, but at a slight elevation the sides become perfectly flattened planes, and as such are carried up to the required height."

The food of the larvæ, as of the perfect Wasps, consists in part of honey, which the latter obtain either directly from flowers or by plundering the Bees, in part of portions of succulent fruits, and in part of animal matters, and as soon as her first eggs are hatched the parent Wasp furnishes the larvæ with the necessary supplies of food. When their development is completed the young Wasps pass but a short time in the pupa state, and then emerge in the form of workers, which at once assist the female in the labours of the nest. Fresh combs are added beneath the foundation comb; the protective covering is enlarged and carried down in proportion as the building of the cells progresses, until at last, in the case of the Common Wasp and many other species, the nest forms a large ovate body, with a surface of rough paper, having a single opening for the ingress and egress of the inhabitants at the bottom. Within this the great business of reproduction goes on rapidly; workers are produced in great numbers; then females make their appearance, and finally males—the last only at the approach of autumn. After these and the young females have quitted the nest for their nuptial flight, the remaining inhabitants of the nest seem to have some consciousness that the end of their own lives is approaching, and that they will be unable to rear the young brood still in the combs. By a singular instinct, they proceed to pull the grubs out of the cells, carry them outside of the nest, and, after conveying them some distance from its entrance, drop them on the ground to die.

The general habits of the Social Wasps are pretty uniform except in the matter of their architecture, and in this respect they display a remarkable variety. Besides the Common Wasp (*Vespa vulgaris*), two other species found in Britain which build in the ground follow the same principles in the construction of their nests; but the Hornet (*Vespa crabro*), which is remarkable among European Wasps for its large size, builds its nest usually in the hollow of a tree, and the material of which it is composed is derived from the bark of trees, and often betrays its diversity of origin by the different colours of the successive portions added to the structure. Both the Hornet and the Common Wasp frequently build their nests under the eaves of houses, or attached to a beam under the roof, and in these cases the outer covering of the nest is thinner and more delicate in texture than when the dwelling is exposed to the vicissitudes of the weather. Some species of the genus *Vespa* make nests without any covering, and this is the general case with those of another genus (*Polistes*), the numerous species of which are spread over all parts of the world. The nests of these insects consist of combs of various sizes attached by means of short columns to the twigs and smaller branches of trees and shrubs, and freely exposed to the air. One well-known species is the *Polistes gallica*, which is common in France and Germany and throughout the south of Europe. Upon this species Prof. Siebold made some interesting observations confirmatory of his theory that the males of the Social Hymenoptera are produced from the unfertilised eggs of workers or females. Other species, of which the best-known inhabiting Britain is the Wood Wasp (*Vespa sylvestris*), build more or less oval nests, which they

suspend from the branches of trees. These nests have a comparatively smooth outer covering, with an aperture at the bottom, through which the Wasps pass in and out. The species of *Polybia*, and nearly allied genera, which are numerous in South America, produce a great variety of nests. Thus one species (*P. sedula*) suspends its nest by two or three short stalks from the twig of a tree, and as comb after comb is added the outer walls are carried down to unite and suspend the lower ones, so that the nest consists of a series of storeys, access to each of which is obtained by a small aperture in the outer wall leading into the space between two combs. Another (*P. rejecta*) builds its nest on the same general principles as the last, but leaves no apertures in the side walls. Instead of these access is obtained to the upper combs through vacant spaces left in the centre of all except the first. Some species of *Polybia* build their nests of earthy materials. The large size of many of these nests demonstrates the great number of individuals that live together in them. A nest of *Polybia liliacea* in the Paris Museum measures about five feet in length. *Tatua morio*, a common species in Cayenne, builds its nest on much the same principle as *Polybia rejecta*, but the apertures for access to the successive combs are placed on one side near the wall of the nest. Other species of the genus *Polybia* build nests agreeing in general construction with those of our indigenous Wasps when attached to trees; others, again, build their successive combs upon a twig or slender branch, which, passing through them, serves the purpose of a series of uniting columns; whilst one species (*Chartergus apicalis*) places each of its combs at the end of a short column springing nearly at a right angle from the supporting branch. All these nests have a protective covering.


POLISTES GALLICA AND NEST.

Although we have only been able to refer in general terms to a few of the almost endless variety of beautiful structures made by the social forms, we must pass on to the Solitary Wasps (Eumenides), in which only true males and true females occur, and which are distinguished from the preceding by their deeply-toothed or bifid tarsal claws, and their generally long and slender mandibles. These are usually considerably smaller than our ordinary Wasps, but are nevertheless unmistakably wasp-like in aspect. They are generally black, with the thorax more or less spotted and the abdomen ringed with yellow. The species are tolerably numerous and widely distributed. They breed chiefly in holes, which the female makes in various situations, sandy banks, dead and decaying wood, and old walls being preferred; but some of them construct small nests of earthy materials in which to deposit their eggs. The nests are generally furnished with a supply of insects or their larvæ, which the little freebooters ruthlessly seize and carry off for the sustenance of their offspring.

One of the commonest and best known species is the Wall Wasp (*Odynerus parietum*), which may be almost constantly seen haunting sunny walls during the months of June and July. It makes its burrows in walls and clay banks, digging out with its mandibles a small hole which may be three or four inches deep, and employing part of the materials removed in building outside the hole a tubular passage leading to it, which at first projects straight from the wall, but towards the end bends downwards. The object of this outwork may no doubt be to prevent the ingress of certain parasites, especially the Gold Wasps (Chrysididæ), which are incessantly prowling about with the object of introducing their eggs into the nests of other Hymenoptera; but Dr. Taschenberg thinks that it is simply for the purpose of having the materials at hand for the purpose of closing up the nest when finished and stored. It may probably serve both purposes. The provisions carried into the nest when completed consist of small larvæ of Beetles or Lepidoptera. The insect grasps her booty with her jaws near the head, holds it under her body by means of her legs, flies with it to the nest, and conveys it to the further end of the cavity, where it is carefully packed away, curled into a ring-like

form, its power of movement having been paralysed by the sting of the Wasp. Other larvæ are brought in until a sufficient supply has been accumulated, when an egg is deposited with them and the nest closed up. Other species of the genus have similar habits, and those which form their nests in dead and rotten wood, bramble sticks, and similar situations, follow much the same mode of life, except that they frequently divide their nests into several cells by earthen partitions. The larvæ stored in the nests generally belong all to the same species.

The species of the genus *Eumenes* and its allies have the first segment of the abdomen very slender towards its junction with the thorax, enlarged behind, and then again slightly constricted, so that it has somewhat a pear shape, whence the only British species was named by Linnæus *Vespa coarctata.* This species, which is not uncommon on the continent of Europe, although scarce in Britain, constructs small globular nests of mud about the size of a hazel-nut, and attaches them either to the twigs of shrubs or to the surfaces of rocks and walls. These nests are stored by the female with small green larvæ, and it is supposed that two broods are produced in the year.

A few species, forming the group Masarides, which chiefly inhabit warm countries, are distinguished by having only two submarginal cells in the fore wings, which are also often only partially capable of being folded. Two species (*Celonites apiformis* and *Ceramius Fonscolombi*) occur in Southern Europe.

FAMILY CRABRONIDÆ.

This family includes a considerable number of more or less wasp-like insects, often presenting the same livery of yellow and black that is so common among the solitary Wasps, but occasionally showing a red and black coloration, reminding us of the insects of the next family. The Crabronidæ (or Sphegidæ—as they are sometimes called) may, however, be distinguished from the members of both these families by the circumstance that the prothorax is not produced at the sides so as to reach the bases of the fore wings, but reduced to the ring-like structure that we have already stated to be characteristic of the Hymenoptera generally; and as a further difference from the true Wasps, it must be noted that their wings are not capable of being folded longitudinally. These insects never form societies, and all the individuals are therefore either true males or true females; the antennæ are generally short, and not geniculated; the eyes are generally oval, and the ocelli distinct; there are from one to three sub-marginal cells in the fore wings; the tibiæ and tarsi are spinous.

In their habits, the Crabronidæ present a considerable resemblance to the Solitary Wasps. The females deposit their eggs in cells which are usually formed in the ground at the extremity of a passage of some length, but sometimes in dead or decaying wood, or in the branches of brambles, and other shrubs or trees, or built of earthy materials against walls, &c.; and the food of the larvæ consists of various insects, which the mother generally paralyses by stinging them in the belly, so as to pierce the nervous cord, and then packs into the cell in sufficient quantity to supply her offspring with nourishment until it attains its full development. The egg is then deposited, and the nest closed. The victims belong to various groups of insects, and include small larvæ of Lepidoptera and Beetles, and Grasshoppers, perfect Beetles, Flies, and even Bees, besides Spiders, &c. Some species, instead of rendering their prey helpless by stinging them, kill them outright by a severe bite. These latter do not store and close their cells, but leave them open, and bring in fresh supplies of food until the larva is full-grown. Here also, as among the Bees, we find some Cuckoo-like types, which make no nests, but deposit their eggs in the cells prepared by their more industrious relatives.

The typical genus *Crabro* is a very extensive one, including over 150 species, a great proportion of which are inhabitants of Europe, while even Britain possesses more than thirty-five. They are black and yellow insects of small and moderate size. They have only a single sub-marginal cell in the fore wings, and the males in many species have the anterior tibiæ and part of the tarsal joints dilated into curious plates, which are sometimes apparently perforated like a sieve, a character which has gained the largest of the British species the name of *Crabro cribrarius.* This species, and many others, burrow in the ground, generally in hard sandbanks, and provision their nests with Gnats and other Dipterous insects. One species (*C. brevis*), which frequents the same situations, has been found to carry in small Beetles of the genus *Haltica;* and another, which was observed making its nests in the mortar of old walls, provisioned them with *Aphides* from the rose. Many species,

including *C. sexmaculatus* and *C. vagus*, which are very abundant in Britain, make their burrows in decaying wood, old posts, and the dead trunks of trees, and also show a preference for Dipterous Flies. A few occupy the pith cavity of bramble and rose sticks with their little cells.

The species of *Cerceris*, which have the junctions of the abdominal segments strongly constricted, for the most part collect small Beetles as a provision for their larvæ, Weevils of various kinds being apparently preferred. Some of the exotic species are of considerable size—upwards of an inch in length—and of great beauty. One of them attacks species of Buprestidæ, and another provisions its nest with Honey Bees. The great enemies of the Bees, however, are the species of the genus *Philanthus*, which are numerous, and distributed nearly all over the world. We have one British species (*Philanthus triangulum*), which is very local in this country, and forms its burrows in sandy places. In the Isle of Wight Mr. Smith observed it provisioning its nest with hive Bees, and two species of Andrenidæ. This insect (which has also been called *Philanthus apivorus*, from its Bee-eating habits) lies in wait for its victims among the flowers which they frequent, and, on their settling in search of honey, dashes upon them, seizes them with its strong mandibles between the head and the thorax, and stings them in the abdomen. The Bee, being thus rendered quite helpless, is grasped by the jaws and legs of its assailant, and immediately carried off to be deposited in the nest of the latter. The nest is a tunnel made in some bare sandy spot, often in a path, carried down for some distance, more or less perpendicularly, and then turned horizontally parallel to the surface.

PHILANTHUS TRIANGULUM AND NEST.

The large species of the genus *Sphex*, some of which grow to a length of about two inches, make war upon the Grasshoppers which abound in warm sandy places. These insects, in attacking their bulky prey, use every endeavour to turn the Grasshopper on his back. When they succeed in this they clasp his long hind legs with their fore feet, and standing over him inflict two stings, one in the neck and the other in the suture between the pro- and meso-sternum, and these soon paralyse the victim, which is then dragged to the nest of its ruthless destroyer. *Sphex flavipennis*, a well-known species of the south of Europe, furnishes each nest with about four Grasshoppers, the soft interior parts of which are speedily devoured by the voracious larva, the hard, chitinous skin being left almost uninjured.

In several tropical species of *Cerceris* and *Philanthus* the first segment of the abdomen is much elongated, forming a long slender footstalk; in another genus of these Sand Wasps (*Ammophila*)

which is perhaps the most widely distributed of any, and of which two species are exceedingly abundant in Britain, the petiole of the abdomen is similarly elongated, and in some species the first two segments take part in its formation. This is the case in the common British Sand Wasp (*Ammophila sabulosa*), a formidable insect nearly an inch in length, having the head and thorax black and hairy, the second and third segments of the abdomen red, and the remainder black. The abdomen is strongly clubbed. This insect is very common in sandy places, and stores its nest with Caterpillars, of which the female under favourable circumstances lays in a store of three or four according to their size in each cell. She stops the entrance of her burrow with a small heap of stones after depositing each Caterpillar, and should bad weather intervene before the whole necessary store has been accumulated, she will bring in further supplies as soon as the opportunity offers. *Ammophila hirsuta*, another British species, with a shorter abdominal petiole and a more hairy surface than the preceding, is said by Mr. F. Smith to provision its nest with spiders. This is the case also with another long-stalked species (*Pelopœus spirifex*), which occurs commonly in central and southern France and other countries bordering the Mediterranean, and differs from all that have been hitherto noticed by its habit of building a nest of clay, containing several cells, in sheltered situations, about walls, barns, and houses. The female builds cell after cell, storing them with Spiders and laying an egg in each as she completes them. *Pemphredon lugubris*, a very common small European and British species, of a uniform black colour, burrows into decaying wood and in bramble sticks, and stores its cells with Aphides, which it collects and scrapes together into a ball in a most unceremonious manner.

PELOPÆUS SPIRIFEX AND NEST.

FAMILY POMPILIDÆ.

The Pompilidæ agree in general structure, and also in habits, with the insects of the last family, with which and the two following families they used formerly to be grouped under the name of Fossorial or Digging Hymenoptera, from their general practice of digging burrows for the reception of their eggs. The chief point of difference between the Pompilidæ and the Crabronidæ consists in the structure of the prothorax, which in the former is produced on each side as far as the root of the wings—as in the True Wasps—but the wings are incapable of being folded longitudinally, and they are generally large and broad, with three sub-marginal cells. The antennæ are long, and not

kneed; the eyes are not notched within; and the legs are long, with spinose tibiæ, which have long spines at the apex. There is no striking difference between the two sexes. There are some 700 or 800 known species, and they occur in all parts of the world, the range of the typical genus (*Pompilus*) extending from Lapland to the Cape of Good Hope, and from China to Chili. Many tropical species are of large size and great beauty, some of them being adorned with bands of silvery pile, and having the wings richly coloured.

Most of the species of *Pompilus* burrow in sand, or sandy soil, and store their nests with Spiders and the larvæ of insects—generally the former—with which they wage constant war, and it would appear that as a rule the females of each species show a decided preference for certain kinds of victims in storing their nests. Their behaviour with large spiders shows great boldness. They attack their intended prey vigorously and continuously until, apparently in despair, the Spider throws himself upon his back, when he contrives to repel the assaults of his enemy for a time by the action of his legs; but on his becoming exhausted the Wasp dashes in upon him, seizes him with her jaws beneath the breast, and speedily paralyses him by two or three stings in the abdomen. The Wasp then, after inspecting her victim on all sides, to make sure of its being in a helpless condition, seizes it by the fore part of the body, and drags it away to her nest. Smaller Spiders and Caterpillars naturally give less trouble.

One of our commonest species, the *Pompilus fuscus*, is usually about half an inch long, and is black, with the first three segments of the abdomen red, and banded with black. The wings are brownish, with the tips black. This insect makes its appearance in the spring, and may be observed in sandy places throughout the summer. It burrows in the sand to a depth of three or four inches, digging out the sand with its fore legs after the fashion of a terrier dog. It is said to provision its nest with various supplies, but prefers Spiders. Some species, which have the anterior tarsi destitute of the fringes of bristles, construct cells of mud very similar to those of *Pelopæus*. The British *Pompilus punctum*, a small black species, is one of these.

The species of *Ceropales*, which also have no fringes on the tarsi, and the legs almost destitute of spines, are further remarkable for having the posterior legs unusually long, and are believed to act the Cuckoo part—depositing their eggs in the nests of other Pompilidæ. Although not numerous in species, the genus is very widely dispersed over the face of the earth. Two species occur in Britain.

Pepsis is a peculiarly American genus, its species being almost entirely confined to South America. Most of them are of large size and great beauty. *Pepsis heros*, a species found in Cuba, attains a length of two inches, and is of a deep black, with a dark blue lustre on the head, abdomen, and legs; whilst the wings are reddish, with a metallic tinge and a dark brown margin.

FAMILY SAPYGIDÆ.

This is a small family, containing only a single genus, with very few species. Like the Pompilidæ the insects referred to it have the prothorax produced to the base of the wings on each side, a character which also occurs in the next family; but the legs are destitute of spines, the hind legs do not extend beyond the tip of the abdomen; the antennæ are long, and usually more or less clubbed; the eyes are notched on the inner margin; and the sexes are alike in form, both being winged. The species of *Sapyga* occur in Europe and North America. They are supposed to be parasitic in the nests of Bees, and the females are found in the neighbourhood of the burrows of the latter; but the females of the common European and British species (*Sapyga pacca*, or *punctata*) have been observed carrying small Caterpillars, from which Mr. Smith, with justice, infers that they are parasitic only to the extent of usurping the burrows made in sandbanks and dead wood by more industrious insects, their own structure not adapting them for the labour of digging. The species above mentioned, which varies between one-third of an inch and half an inch in length, is black, with the abdomen partly red in the female, and both sexes have transverse white spots on some of the abdominal segments. This species haunts the nests of species of *Osmia*. The largest species of the group (*Sapyga repanda*) is similarly attached to the great Carpenter Bee (*Xylocopa*).

FAMILY MUTILLIDÆ.

In this family, which completes the series of so-called Fossorial Hymenoptera, we still find the prothorax extending at the sides to the base of the fore wings when these are present; but the males

and females differ greatly from each other in many respects, the latter being often destitute of wings, or having those organs greatly reduced in size, whence the name *Heterogyna* has been given to the group by many entomologists. In both sexes, however, the legs are comparatively short and hairy, or spinose, but with long tarsi; the eyes are notched on the inner margin; and between the first and second segments of the abdomen there is a notch or constriction. The group includes a large number of species—probably 1,200 or 1,300—but from the differences presented by the males and females entomologists have found it difficult to arrive at any certainty upon this point. The species are spread over all the earth, but particularly abundant in warm climates, where also, as usual, they attain the largest size and the most beautiful colouring.

In the genus *Mutilla*, from which the family name is derived, and in the allied genera, which include the great bulk of the species, the peculiarities of the group are most strongly marked, and the differences between the sexes so striking that until comparatively recent times the males and females, even of well-known species, were referred to distinct genera, and sometimes rather widely separated. Of *Mutilla* some 500 species are known from all parts of the world, and three of them occur in this country. They are found usually in sandy spots. In this genus the females have no ocelli. The most abundant European and British species (*Mutilla europæa*) is about half an inch long, of a black colour, hairy, with the thorax entirely red in the wingless females, red in the middle in the winged males; the abdomen has three transverse bands of white or yellowish hairs, the two hinder of which are interrupted in the middle. The wings of the male are brownish. The females of this and other species have an aspect intermediate between that of a Spider and that of an Ant, whence the German entomologists give them the very characteristic name of "Spider Ants." The habits of the species are not very well known. The *Mutilla europæa* frequents the nests of Humble Bees, and its larvæ appear to be parasitic upon the larvæ of the Bees. Mr. Drewsen of Copenhagen obtained only two Worker Bees from a nest of *Bombus skrimshiranus* taken by him, which furnished seventy-six examples of *Mutilla europæa*, forty-four males and thirty-two females. The larvæ of the *Mutilla* were found in the cocoons which had been formed by the full-grown larvæ of the Bee. The females, after impregnation, pass the winter rolled up in the ground or under stones. Both sexes of this and other species can produce a faint chirruping sound by the friction of the third and fourth abdominal segments upon one another; and the special arrangements for producing this noise consist of a small triangular finely-ribbed area upon the upper surface of the fourth segment, over which passes the hinder margin of the third segment, furnished beneath with a little sharp ridge. These parts are rubbed together by the extension and retraction of the fourth segment, which slides in and out of the third like the draw-tube of a telescope.

MUTILLA EUROPÆA.

A great number of species of *Mutilla* occur in South America, which is also the home of another important genus (*Thynnus*), likewise largely represented in Australia.

In another group of the family, formed by the genus *Scolia* and its allies, the female is winged,

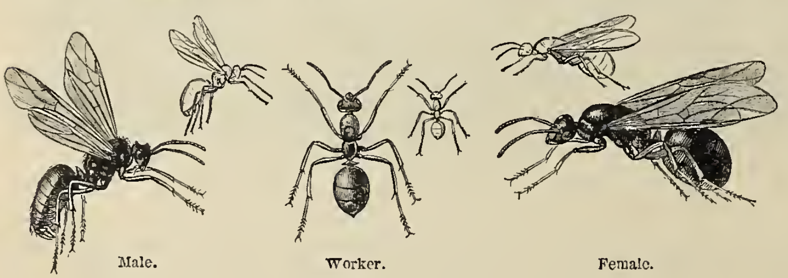
and generally presents rather less divergence from her partner than in the more typical genera just referred to. Nevertheless, there are important differences between the sexes; the male has long and nearly straight antennæ, while those of the female are short and bent; the female is generally larger and more robust than the male; and they frequently differ in coloration, sculpture, hairiness, and other characters to which we cannot here refer. The *Scoliæ* are large and powerful Hymenoptera, some of them attaining a length of two inches, and they are armed with very formidable stings. They chiefly inhabit warm countries, and their larvæ usually feed upon the grubs of large Beetles.

The British forms of this group belong to a distinct genus (*Tiphia*), and are of small size. They are not abundant. Mr. F. Smith notices the frequent occurrence of the commonest of them (*Tiphia femorata*) under the droppings of cattle, from which he was led to suspect that they might be parasitic upon the larva of some coprophagous Beetle.

FAMILY FORMICIDÆ.

In this family, which includes the various species of Ants, we have to do once more, and for the last time, with social insects organised after the fashion of the Bees and Wasps—that is to say, in which the community is permanently made up of infertile females, or workers, with one or more perfect females for egg-laying purposes, and only at a certain season of a larger number of females and males. As in the case of the Hive Bee, the communities of Ants are generally permanent. The economy of these insects presents some of the most interesting phenomena that the study of zoology has to offer, and the writer's difficulty is to select from the mass of materials extant what will suffice to give some notion of the natural history of the group.

Even the character that must be given of the family is a complex affair. The males and females are winged on their emergence from their cocoons; the workers are always wingless. After the nuptial flight the males die, and the females drop, or even pull off their wings; but the latter have the thorax broad, and of the ordinary Hymenopterous type, with the meso-thorax much developed for the support of the large anterior wings. In the workers, on the contrary, the whole thorax is slender, and the prothorax is the most developed segment. In the males and females the head is comparatively small; in the workers larger; and in many cases two forms of workers exist—one with a head of ordinary size, the other with this part wholly out of proportion to the rest of the body, and armed with formidable jaws. These large-headed workers are commonly called "Soldiers," and their function is supposed to be to fight in defence of the nest. The antennæ are generally kneed, with a long first joint, except in the males of some types, in which the first joint is not much elongated, and the geniculation is inconspicuous. The eyes are large in the males and females, always small and sometimes rudimentary in the workers; and the ocelli, which are always present in the males and females, are generally entirely wanting in the workers. In the wings, there is usually only one submarginal cell, never more than two. The first, or first and second, segments of the abdomen form a stalk, or *petiole*, very distinctly separated from the rest of the abdomen, which is ovate, heart-shaped, or sub-globular in form; and these segments bear a knot, or transverse scale, the presence of which is one of the most easily-recognisable characters of the family. The females and workers frequently possess a regular sting, which they use vigorously in their own defence. Others have no sting, but most of these possess glands, secreting an acrid fluid containing formic acid, which they can inject into the wounds produced by their mandibles.



Male. Worker. Female.

THE WOOD ANT.

The Ants are generally small and often minute insects, which swarm in all parts of the world, but are most abundant, both in species and individuals, in tropical countries, where also the largest forms occur. The number of described species is probably over a thousand, but the total number must be considerably greater, if Mr. Bates is correct in his estimate that not less than 400 species inhabit the valley of the Amazon.

The general habits of the species may be succinctly described as follows. The nests are almost always chambered cavities, hollowed out either in the ground, in walls and similar situations, or in dead and decaying wood. A distinguished Swiss naturalist, M. Forel, has classified the different kinds of nests made by the Ants of Switzerland, and his observations will generally apply equally to those of other countries. He describes the following categories :—1. *Ground nests*, consisting either of galleries burrowed in the earth, sometimes exposed, sometimes protected by being made under a stone, or of similar galleries and chambers, surmounted by a chambered hill, built up of the materials removed from the subterranean dwelling. One of the commonest examples of this series is the common GARDEN ANT (*Formica nigra*), which may be found everywhere in gardens, making its nest in the ground, but often taking advantage of an inverted flower-pot to throw up under cover a mass of fine mould, traversed by chambers and galleries in all directions. Another is the pretty little TURF ANT (*Formica flava*), which generally haunts commons and heaths, casting up small hills, which serve to throw off the rain, and this species in some localities makes its nest under stones. 2. *Wood nests*, consisting of chambers and galleries hollowed out by the insects in the substance of trees, posts, &c. The course followed by the Ants in the excavation of their dwellings in wood seems to be governed, to a certain extent, by the direction of the fibres of the wood. The WOOD ANT (*Formica ligniperda*) practises this method of architecture. Some minute Ants, forming the genus *Leptothorax*, bore into the bark of trees, and there make their nests, consisting of a few chambers. 3. *Paper nests*, of which the only Swiss examples are those of the JET ANT (*Formica fuliginosa*), a well-known British species, which is provided with greatly-developed salivary glands, secreting a very tenacious fluid, by means of which the Ants produce a sort of cardboard from masticated wood-dust, and use this in the fabrication of their dwellings. Their nests are usually situated in stumps of trees. 4. *Composite nests*, of which those of the WOOD ANT (*Formica nefa*), so common in our woods and forests, may serve as an example. The nests of these insects, as is well known, consist of a great heap of small fragments of sticks and other vegetable substances most artificially put together so as to form the necessary galleries and chambers for the economy of the community. M. Forel also refers to this class, the nests made in rotten tree-stumps, in which the extremely decayed wood is used in the same way as the earth by other species for the construction of their dwellings. 5. *Diverse nests*, or those which cannot be brought under any of the preceding definitions, such as the dwellings formed by Ants in the fissures of walls and rocks, in houses, &c.

The size of the nest depends upon that of the community to be sheltered by it, and in the larger ones the complication of passages and chambers in several storeys becomes very great. Certain passages lead directly to the surface of the nest, where there are openings permitting the egress and ingress of the inhabitants, but these are in general carefully closed at the approach of night. Besides these simple doorways, many species make passages leading out of the nest, sometimes to a considerable distance, which serve as covered ways for the Ants in going to and from their favourite feeding grounds.

Although the communities of Ants are permanent, the males of course are only to be found in the nests for a certain time, but in the case of some species this period seems to be much longer than in the Social Bees and Wasps. In many instances the females also disappear after depositing the last batch of eggs of the autumn season, and thus the nest in the spring contains only workers with larvæ and pupæ. The larvæ of this last brood are carried down by the workers into the deepest recesses of the nest, where they pass the winter in a state of torpidity. In the majority of species, however, the females appear to survive from season to season, but it is not believed that they live more than one year. The eggs and larvæ are carefully attended to by the workers, the latter being fed by them, and both being carried from one part of the nest to another, so as to be placed always in the most favourable conditions for their development, or conveyed into the penetralia of the nest should any danger threaten the community. Later on the larvæ become converted into pupæ, many of them first enclosing themselves in a small silken cocoon.* The pupæ are still the

* The group of the Myrmicinæ, characterised by having two knots or scales in the petiole of the abdomen, includes species which usually spin no cocoons. In the rest of the family (Formicinæ), although the formation of the cocoon is the rule, it is liable to many exceptions, and, indeed, pupæ with and without cocoons are said to occur in the same nest. The pupæ in cocoons are the objects commonly known as "Ants' eggs," and sold under that name as food for the soft-billed singing birds.

objects of the most assiduous care on the part of their foster-mothers. From them are produced new workers, and in the course of the summer a number of winged males and females, which remain in the nest until their instincts tell them that the conditions of weather outside are favourable for them to take their nuptial flight. The several individuals of the same species over a considerable district generally fly out on the same day, and in this way often produce the effect of dark clouds, especially when, in obedience to an instinct that prompts them to hover about an elevated object, they select the summit of the steeple of a church or of some lofty tower as a place of rendezvous.

Of course, during these vagaries immense numbers of the insects fall a prey to birds, and those of the males which escape this fate probably perish soon after their return to the ground. The females, on the other hand, after their descent, may be seen running about with their wings in a more or less dislocated condition. The wings, in fact, drop off, or are pulled off very soon after the females reach the ground, and they then either establish a new nest after the fashion of the Wasps and Humble Bees, or find their way into an established nest of their own species. These fertilised females then furnish eggs for the continuance of the species, and the larvæ hatched from them are fed and cared for by the workers, as already described.

The duties of the workers are, in fact, as multifarious as those of the worker Bees. They have the care of the construction, maintenance, and enlargement of the common dwelling, and upon them also depends its defence from enemies, in which they display the greatest courage and determination. As already mentioned, in some species there is a special kind of worker (soldiers), whose supposed duty it is to protect the nest from invaders, and in these the head is very large, and the mandibles correspondingly powerful; but even the ordinary workers are exceedingly courageous when called upon to defend their home. A further duty is the bringing in of provisions, and in this the workers are indefatigable. Their food consists of both animal and vegetable matters, and, like the Bees, they are particularly fond of saccharine substances, which they obtain from flowers and fruit, and also from the Aphides, or Plant-lice. These insects secrete a sweet fluid, which flows in the form of clear drops from two small tubules placed on the sides of the abdomen near its extremity; these drops the Ants greedily suck in, and they have the art of inducing the Aphides to produce further supplies of the same liquid by gently stroking them with their antennæ, a process which has been not inaptly compared to milking. Of animal food, scarcely anything comes amiss to them; the flesh and other soft parts of small dead animals that may chance to lie near the nests of Ants are speedily cleared away; and many tropical species immediately attack and destroy insects much larger than themselves, overcoming all their struggles by mere force of numbers. The larvæ are fed upon drops of fluid disgorged by the workers.

The labours of the workers on behalf of the young are not, however, limited to feeding them. In fine weather, and in the middle of the day, the larvæ and pupæ are brought into the more superficial chambers of the nest, or even sometimes quite outside of it; at the approach of night, or of bad weather, they are conveyed to the most deeply-seated apartments, where they may be protected from injurious influences. The anxiety of the workers for the safety of their helpless charges is always strikingly manifested in the case of any injury to the nest. If a portion of the outside be broken down, a crowd of workers instantly rush to the breach, a part of them setting to work at once to repair the damages, while others immediately seize upon any larvæ and pupæ that may be mingled with the ruins, and bear them off in their mandibles to a place of safety.

There are so many remarkable facts known about these most interesting insects, that one is embarrassed in selecting what will serve best for the completion of the general sketch of their history, which is all we can hope to give here. One very singular fact is that although it has been repeatedly proved that the inhabitants of a nest will severely maltreat and even kill individuals of the same species belonging to a different nest, which may by chance intrude into their dwelling, not only may nests belonging to the same species be found in juxtaposition upon the same piece of ground, and furnished with passages establishing free intercommunication between the separate nests, but in a great many cases colonies of different species inhabit the same nest. Thus *Stenamma Westwoodii*, a small species of the double-knotted group of Ants, has never been met with except in the nests of the great Wood Ant (*Formica rufa*) and an allied species (*F. congerens*); and although nothing appears to be known of the nature of the connection between these two seemingly incongruous

creatures, we must assume that it is in some way necessary to the smaller species. The Turf Ant (*Formica flava*) is often found occupying one side of its hillock, with a colony of another Myrmicine Ant (*Myrmica scabrinodis*) comfortably established on the other; and other species have been met with residing in strange nests, although they are known to form independent colonies.

A still more curious form of association is that in which certain species of Ants keep the workers of other species to act as their slaves. The Warrior Ant (*Formica sanguinea*), a species not uncommon in some parts of England, is one of these, keeping workers of *Formica fusca*, *F. cunicularia*, and *F. flava* in its nest; but in this case "the institution" appears to be needless, as the workers of *F. sanguinea* take their share in the labours of the community. In this, as in the other cases of the same kind, the slave-making Ants make a descent, after the old robber fashion, upon the societies of the species whose services they are in the habit of usurping, and carry off the larvæ and pupæ to their own nest. The workers produced from these set to work to perform the necessary duties of their new home, just as if it was their proper dwelling-place. With the Amazon Ants, indeed, the imported workers have more to do than they would have had in their own community, for the Amazons are so lazy that they will not even feed themselves, and would perish of starvation if they were not fed by these imported workers.

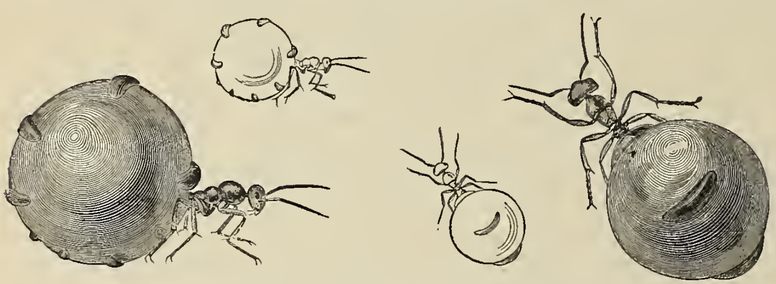
Besides these stranger Ants, other insects are found in the nests of many species, the presence of which is not easily accounted for. The larva of the Rose Beetle (*Cetonia aurata*) is found in the nests of the Wood Ant, where it is said to feed on the rotting fragments of wood forming the lowest part of the nest. Species of the Coleopterous genus *Hister* and Brachelytrous Beetles are met with in Ants' nests, and many of the latter have never been found elsewhere. Several Beetles of the curious family Paussidæ have been found in Ants' nests, and, from the circumstances, it would seem that this is their natural habitat. In Europe a great number of the rarest Beetles are also inhabitants of these nests. According to Dr. Taschenberg, more than 300 species of true Ants'-nest insects, chiefly Beetles, are known in Germany, and of these, 150 are found with the Jet Ant, and 100 with the Wood Ant.

We have already alluded to the fondness of Ants for the sweet fluids excreted by the Aphides from the so-called honey-tubes which project from the sides of the hinder part of their abdomen. In search of these insects, the Ants roam over every part of the trees and plants infested by them, and, not content with imbibing the nectar spontaneously exuded, stroke the Aphides with their antennæ, lick them with their tongues, and coax them in every way to furnish a further supply. Hence the Aphides have been denominated the milch-cows of the Ants; and, as if to make the comparison more complete, the latter frequently set up a right to exclusive property over the Aphides in their neighbourhood. Sometimes this is done simply by making a convenient covered way leading from the nest to the pasture where the Plant-lice are feeding. Sometimes the Ants build a wall, or even a roof, for the protection of their diminutive flock; and, still more frequently, they carry off a number of Plant-lice, and keep them in their subterranean nests, where they feed by sucking the juices from the roots of grasses and other plants in the neighbourhood of the nest.

It will be easily understood that to carry on all these operations for the general weal a considerable amount of organisation is requisite, and this can hardly be attained without some means of communication between the different members of an extensive community which have to work together for a common end. The doings of the Ants sufficiently prove that they possess some means of conveying intelligence to one another, and, so far as can be made out, while mere pulling and pushing serve for some rough purposes, the finer and more particular communications are made by the agency of the antennæ. These organs seem to come into play in almost all circumstances of Ant life; and all writers upon these insects, from the days of Huber downwards, have devoted much of their attention to this most interesting subject. To enter upon it here, however, would lead us into details, for which space is wanting; and we would particularly refer the reader who wishes for more information to the admirable papers by Sir John Lubbock, published in the *Proceedings of the Linnean Society*. The antennal language, whatever may be its nature, would appear, however, not to be the sole means of communication possessed by Ants. Dr. Landois has been induced, by the consideration of the fact that the Spider Ants (*Mutillæ*) have the means of producing sounds by the grating of the edge of one abdominal segment over a finely striated portion of the succeeding one, to examine some species of

Ants in search of a similar arrangement, and found in *Ponera* distinctly developed stridulant organs of the same type as in *Mutilla*, and capable also of producing sounds perceptible by the human ear.

The Formicidæ may be usefully divided into two great groups, namely, the Formicinæ, so named from the typical genus *Formica*, in which the abdominal petiole has only a single knot, or scale; and the Myrmicinæ, including the great genus *Myrmica* and its allies, which have two knots, or scales, on the petiole. Of British species of the former group, we have already referred to several, such as the Great Wood Ant, the Warrior Ant, the Jet Ant, &c. The Wood Ant (*Formica rufa*), which is an exceedingly abundant species, has the head and thorax of a rusty-red colour, with a brownish-black tinge in parts, while the legs and abdomen are almost entirely of the latter colour. The largest workers measure more than a quarter of an inch in length, and the females as much as five lines. This species is found in woods, where it lives in a great heap of vegetable fragments, portions of wood and leaves, small sticks, and the needles of pine trees, beneath which the nest is continued in a great extent of subterranean passages and chambers. In favourable situations these nests attain great dimensions: they may be found more than six feet in diameter, and four or five feet high. Like the other species of the genus, this Ant possesses no sting, but the glands producing the acid secretion are well developed, and it appears to be used not only by injection into wounds inflicted by the mandibles, but also by being ejected, after the fashion of that of the Bombardier Beetles, for the purpose of keeping an enemy at a distance. The Warrior Ant (*Formica sanguinea*) is less common in England than the preceding species. It has the head and thorax of a blood-red colour, instead of rusty-red, and the legs are red. The largest workers attain a length of a third of an inch. Its communities are smaller than those of the Wood Ant, and its nest is frequently constructed in banks. Its habit of making slaves has already been alluded to. The Wood Ant seems to inhabit the greater part of the Northern Hemisphere, and other European species are widely distributed. Other regions, however, have their own peculiar species, and they are particularly abundant in tropical countries, where also they attain a larger size. One of the largest species is the Giant Ant (*Formica gigas*) of the East Indies, of which the female measures an inch long. Some of the species of a nearly-related Indian genus (*Polyrhachis*) are remarkable for making a curious little nest in a curious situation. Mr. T. C. Jerdon, speaking of one of them (*P. nidificans*), says:—"This Ant makes a small nest about half an inch, or rather more, in diameter, of some papyraceous material, which it fixes on a leaf. I have opened two, each of which contained one female and eight or ten workers."



MYRMECOCYSTUS MEXICANUS (*Natural Size and Magnified*).

A very singular species of this group, of which only workers are known, is a Mexican insect, described under the name of *Myrmecocystus mexicanus*. The workers are of two forms—namely, ordinary Formicine small workers, which appear to perform the labours of the community; and a larger form, to the peculiarities of which the name of the genus refers, in which the abdomen is greatly inflated and nearly transparent, but bears upon its surface horny plates, indicative of the segments. These peculiar workers, which are very inactive, seem to have as their sole duty the secretion of a peculiar kind of honey, which they are said to discharge into receptacles.

The genus *Ponera* and its allies, in which the petiole still has only one knot, but the females and workers are armed with stings, include many species of larger size than those hitherto referred to. They are mostly inhabitants of tropical countries, and their history is very imperfectly known. To this group belong the Driver Ants, or Visiting Ants, of West Africa, generally referred to the species *Anomma arcens*, although many entomologists are of opinion that other Ants may have the same habits. The workers of *Anomma arcens* grow to a length of nearly half an inch, and are

destitute of both eyes and ocelli. They are described as marching in vast armies, and by some writers as having no settled place of abode. On their march, which is performed on cloudy days and in the night, they drive everything before them, and destroy not only all the insects they meet with, but even many larger animals, which they are said to attack first of all in the eyes. In this way even large snakes are described as becoming their victims. When they come into the negro villages, and make their way into the houses, the inhabitants are obliged to quit their dwellings, and wait until the Ants have passed. But their visits are attended with certain benefits, which render them not altogether unwelcome. Their appearance in a house is soon revealed by the simultaneous movement of all the rats, mice, lizards, cockroaches, and other vermin which swarm in the dwellings in warm climates, and these are either compelled to decamp hastily, or are caught, killed, and devoured. The Drivers are said to cross rivers by a portion of them making themselves into a living bridge, over which the others pass in safety. When dislodged from their lurking places by sudden floods, they are described as making themselves into a rounded mass, with the pupæ and eggs in the centre, and in this form they float upon the water until they are landed in a safe place, or the flood subsides.


SAUBA ANT.

Of the second group of Ants (the Myrmicinæ), the best known species are the little RED ANTS (*Myrmica ruginodis, scabrinodis,* and *lævinodis*), formerly included under the general name of *Myrmica rubra.* The workers are generally about a sixth of an inch long, and the males and females rather larger. They are met with making their nests in the ground, under stones, in the stumps of trees, &c., and often occur in immense numbers. A very minute Ant, which has been introduced into this country probably from Brazil or the West Indies, is the HOUSE ANT (*Myrmica molesta*). It is a very small brownish-yellow species, which seems to have been first observed in England in 1828. It takes up its abode in houses, frequently in the neighbourhood of the kitchen fireplace; and, when it multiplies, becomes such a pest as to render the house uninhabitable.

This group includes a multitude of interesting exotic species, mostly of larger size than our European forms. In the genus *Eciton,* the species of which are found almost exclusively in Brazil, the workers make expeditions in long and regular columns, pushing out branch columns in the direction of any promising locality. These processions, one of which was observed of a length of from sixty to seventy yards, without either the front or rear of it being visible, are doubtless made commonly for foraging purposes, but singularly enough the insects frequently carry the larvæ in their mandibles. Any insects falling in the way of these expeditions are immediately seized and torn to pieces. *Œcodoma cephalotes,* the SAUBA ANT, also a Brazilian species, lives in enormous communities in subterranean formicaries, the position of which is indicated externally only by a low hill of earth, of rather light colour. These Ants are leaf-cutters, ascending the trees in vast numbers, and cutting pieces out of the leaves about the size of a shilling, which are dropped to the ground, where another multitude is incessantly engaged in gathering up the pieces, and carrying them to the nest. For what purpose these portions of leaves are so laboriously collected it is difficult to say. Mr. Belt thought that the Ants stored them in subterranean chambers for the sake of the fungi which grew upon them there. The *Œcodoma* is not content with such diet, however, but becomes a nuisance in Brazil, by visiting the houses for the purpose of plundering provisions.*

FAMILY CHRYSIDIDÆ, OR GOLDEN WASPS.

Some brilliant little gems of flies, showing the colours of the emerald, the sapphire, and the ruby, with the addition in general of a golden surface tint, form the last family of the Aculeate Hymenoptera. These insects have the antennæ composed of thirteen joints, and bent at the end of the first joint, the eyes oval, and the ocelli distinct. The mouth is constructed after

* For further information on the European Ants the reader may consult the writings of Francis Huber, Latreille, and other older writers, or the summary of their results given in the "Introduction to Entomology" of Kirby and Spence. Sir John Lubbock's valuable papers have already been referred to. Upon exotic Ants, interesting notes will be found in the writings of several travellers, but especially in Mr. Bates's "Naturalist on the Amazons," and Mr. Belt's "Naturalist in Nicaragua." Mr. McCook's articles on Californian and Mexican Ants, published in the "Proceedings of the Academy of Natural Sciences of Philadelphia," are also most interesting.

the usual mandibulate plan, with five-jointed maxillary and four-jointed labial palpi, but the labrum is very small and concealed. The general form of the body is somewhat cylindrical, and it is enclosed in a very hard skin; the abdomen, which is attached to the thorax by a short petiole, shows externally three or four segments, of which the second is very large, and its lower surface is generally hollowed out so as to enable the insect to form itself into a sort of ball after the fashion of a hedgehog or woodlouse. The hinder margin of the last segment is usually toothed, and the number of teeth is often useful in distinguishing the species. Besides these apparent segments, however, the abdomen possesses two or three more, which form a sort of telescopic tube, capable of being retracted within the abdomen, and at the extremity of these is a sting, which, although minute, is able to inflict painful wounds. The venation of the wings is much more simple than in any of the preceding families; there is only one submarginal cell, and even this is not closed.

These insects are of small size, comparatively few of them exceeding half an inch in length. The number of known species is probably between 400 and 500, and they occur in most parts of the world, but are decidedly more plentiful in Europe than elsewhere. All present a very strong family likeness, and their habits are similar throughout the family. About twenty-five British species are recorded, and of these we may take one of the commonest, the *Chrysis ignita,* as the type of the whole. This insect, the Common Gold Wasp, or Ruby-tail, measures from four to five-twelfths of an inch in length, and is of a deep metallic bluish green colour, except the upper surface of the abdomen, which is bright red, with a beautiful golden gloss upon its surface. The whole surface is closely, and more or less coarsely punctured; the thorax is spotted with black; and the apical margin of the abdomen shows four teeth, with a row of ten little pits just in front of them. This beautiful little creature is to be seen almost everywhere during the summer, flying in the hot sunshine, creeping about walls and palings, especially in gardens, and poking its head into every small hole it meets with. This is the female insect, which, when thus occupied, is engaged in looking out for the nest of some Bee or Wasp in which she can lay her eggs. On finding an occupied burrow or nest undefended by the owner, the *Chrysis* immediately makes its way in, and leaves an egg behind her. It appears that the larva hatched from this egg does not make its appearance until the Bee- or Wasp-larva is nearly full-fed; it then attacks and soon devours the latter. The full-grown larva of the *Chrysis* spins a little cocoon within which it passes to the pupa state. Occasionally, when the little Gold Wasp is inspecting the nest of an absent Bee or Wasp, the rightful owner returns, and not unnaturally manifests a good deal of indignation at the intrusion. In such cases the Bee will seize the *Chrysis* with her mandibles, and unceremoniously throw it out of the nest, but the sting of the Bee or Wasp is quite powerless against the hard plate armour in which the parasite is encased. The latter, however, is not easily discouraged; she will make her way back again and again to the nest from which she has been ejected; and when a Bee, losing its temper at the pertinacity of its little enemy, has bitten off the wings of a *Chrysis,* the latter has been seen to unroll itself and crawl up once more to the nest. The finest European species of the family is named *Stilbum splendidum.* It measures from half to seven-twelfths of an inch long, and is usually of a fine blue or emerald green colour, but has the abdomen sometimes golden red. This insect occurs in Southern Europe and throughout Africa and Southern Asia.

CASSELL, PETTER, GALPIN & CO., BELLE SAUVAGE WORKS, LONDON, E.C.